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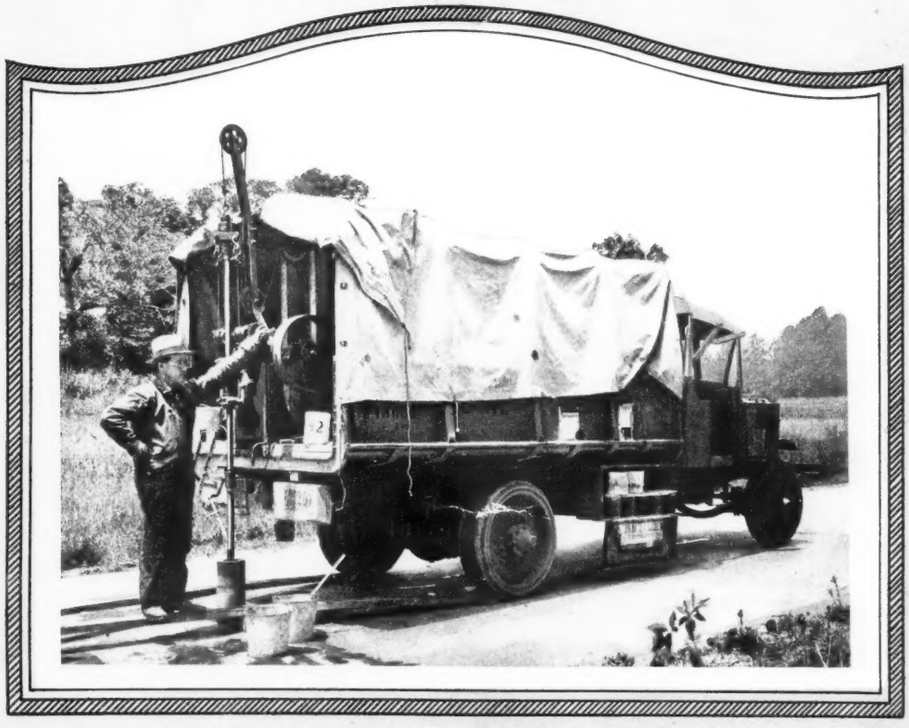

PAVEMENT TESTING "CALYX" CORE DRILL TAKING CORES FROM LINCOLN HIGHWAY

Increasing Niagara Falls Power Development by 200,000 H. P.
G. W. Morrison

Recollections of the Early Days of the Panama Canal
W. L. Saunders

Sending Millions of Air Messages to Countless Homes
Robert G. Skerrett

Underpinning With and Without Compressed Air
Frank W. Skinner

[TABLE OF CONTENTS AND ADVERTISERS' INDEX, PAGE 11]

ONLY THREE OPERATIONS

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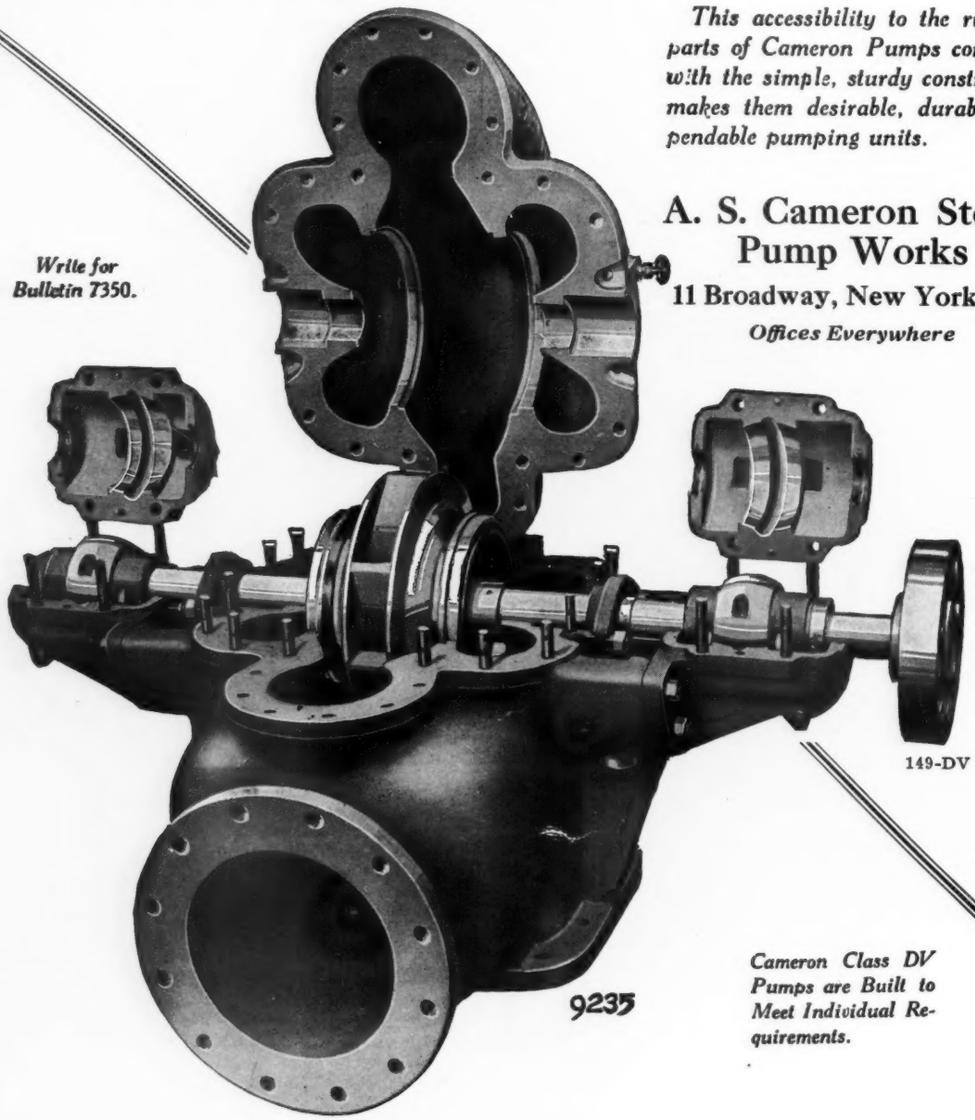

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Increasing Niagara Falls Power Development By 200,000 H. P.

New Project Under Construction by the Niagara Falls Power Company Requires the Driving Through of a 32-ft. Tunnel, a Distance of 4,500 ft., a Most Unusual Rock Drilling Feat

By G. W. MORRISON

IT HAS come to be a generally recognized fact that the development of existing water power resources constitutes one of the main elements in the solution of our growing economic problem. We know that the real source of wealth is power, and in comparison to water power all our other forms of fuel generated energy are of small moment. The power contained in falling water can be obtained constantly for centuries, whereas the energy confined in fuel can be released into useful power only at great loss, and we know from geological science that fuels do not replace themselves within the history of man.

The rapid strides in the development of the gas engine and the heavy oil engine are a part of this power problem, and the more or less tense international situation existing in regard to petroleum resources is only the outcome of what our economists and engineers know will be a deciding factor in commercial supremacy or even, for that matter, of national existence in the future.

However, one phase of this latter question of petroleum supply is that our undeveloped water power resources could be used to a considerable extent to replace the power now developed by gas or oil. The great service that electricity generated from our water power developments renders the community by its use in our homes and industries, particularly in the manufacture of electrochemical and electrothermal products, can be expanded in great measure.

The Niagara frontier is the electrochemical center of the world. The domestic uses of power while of paramount importance to citizens form but a part of the great Niagara power load. The Niagara frontier is a community of manufacture and fabrication and its tremendous demands call for a 24-hour constant and absolutely dependable supply of electricity.

THE NIAGARA Falls Power Co.'s new 200,000 horsepower extension project when completed will be the most modern development of hydro-electric power plants in the world. Throughout the design and construction of this latest unit, maximum efficiency and reliability of operation are being given the highest consideration.

Cheap hydro-electric power is essential for the great electrochemical and electrothermal industries developed in this district within the last 25 years. This power is responsible for the production of many commodities in commercial quantities such as ferro and aluminum alloys, soda alkalies, phosphorous compounds, and many other basic materials all depending upon Niagara power.

Niagara Falls as the source of immense and inexhaustible power is unique. Nothing, of course, is comparable with it anywhere in the world. Many of the world's famous falls are situated in wildernesses, which may in the course of decades become centers of civilization; yet, at the present time Niagara stands alone as a producer of tremendous power which is here developed, transformed into electrical energy, and transmitted for a multiplicity of uses over a great area of this continent. Today about twenty per cent. of Niagara's power is harnessed, serving perhaps three million people with light, heat and power.

It was in the year 1890 that such an eminent engineer as George Westinghouse made the statement, after careful consideration of the project, that the only method of bringing the power from the Falls of Niagara to Buffalo, a distance of only 25 miles, would be by using the power to compress air and force it through high pressure lines to Buffalo, where it could be utilized to operate engines or motors. As an indication of the wonderfully quick development of the methods of generation and utilization of electric power in this country, only three years elapsed from the year 1890 until the initial installation of generators and distributing lines was commenced.

However, in this connection it is interesting to note that this new project of The Niagara Falls Power Company has been, to a great extent, made possible only by the use of the existing electrical energy, which is available for compressing air, which in turn operates the drills for driving the tunnel; that is, the conditions are just the reverse of what Westinghouse expected would occur.

The Niagara River is the natural outlet of the four Great Lakes—Superior, Michigan, Huron, and Erie. These lakes are a natural storage for the rainfall of a drainage area of approximately 250,000 square miles. Sixty per cent. of this area is in the United States. This is a greater area than the State of Texas, and is two and a half times the size of France. The land area on the United States side of the line is greater than the combined area of New England and New York. The water surface of the Great Lakes drainage system is approximately 95,000 square miles. The shore line extends 8,300 miles. The population of the district is 15,000,000, of which 2,000,000 only are in Canada and 13,000,000 in the United States. In this territory there are at least sixteen cities in excess of 50,000 population.

The total developable water power of the

Showing the excavating of the intake for the tunnel. The present hydraulic canal is in the foreground.

basin is estimated by U. S. Army Engineers at 10,000,000 horse power, more than half of this being in the United States. The present water power developed in the Great Lakes district is, roughly, 1,c00,000 horse power in the United States and 1,500,000 in Canada.

Returning more specifically to the Niagara district, the Niagara River carries the natural overflow from the great storage provided by these four lakes. There is a constant average flow of 210,000 cubic feet per second. At present the diversion of water for power purposes is limited by a treaty between the United States and Great Britain to 20,000 c.f.s. on the American side and 36,000 c.f.s. on the Canadian side. This is approximately 25 per cent. of the total flow.

The present development of hydro power at Niagara Falls is approximately 350,000 horse power on the American side and 450,000 horse power on the Canadian side. All of the generating plants on the American side and one of the Canadian plants are under the control of the American company known as The Niagara Falls Power Company, the largest producers of electricity in the world, so that the American interests control a total of 450,000 horse power.

The two remaining plants on the Canadian side are under the control of the Hydro-Electric Power Commission of Ontario, a government ownership plan, and have a total installed capacity of approximately 350,000 horse power. This commission has a new plant under construction, which, when completed, will add 300,-000 horse power or more to its capacity. The new project under way by The Niagara Falls Power Company will, when completed, add 200,000 horse power to the total installed capacity. The cost of this new installation is expected to be approximately $11,000,000.

It may be said here that The Niagara Falls Power Company, while being not only the largest producer of electricity in the world, leading the next largest system by a wide margin, operates and maintains the public service under the most economical conditions. Its load factor and its efficiency are among the highest of all plants in America.

Electricity from Niagara Falls, Ontario, is transmitted as far east as Toronto, and as far west as Windsor, opposite Detroit. On the American side power is transmitted as far east as Syracuse and as far west as Mayville, N. Y.

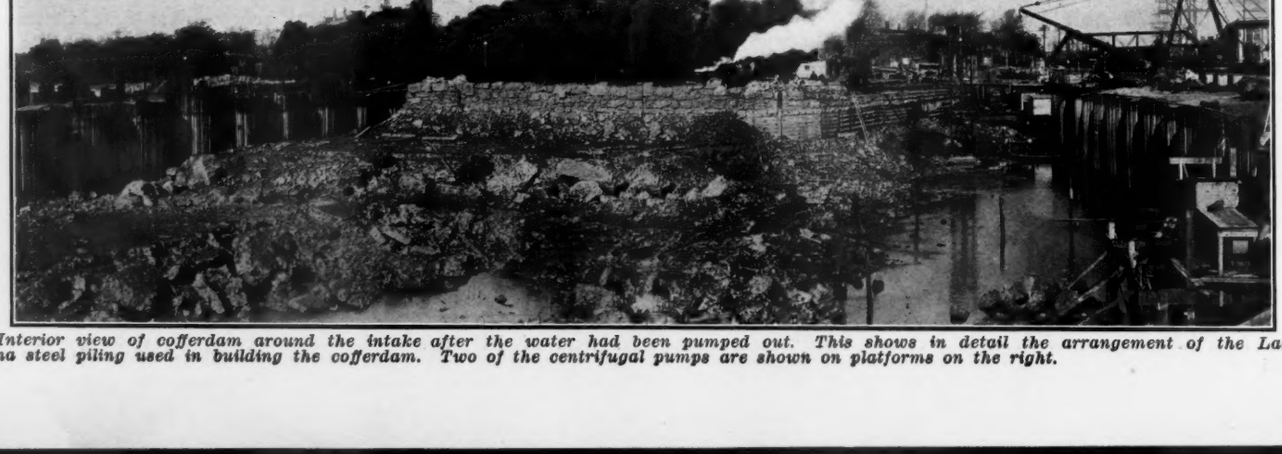
According to the report of Col. J. G. Warren, Division Engineer, Corps of Engineers, U. S. Army, it is possible to utilize up to 60 per cent. of the total flow of Niagara for power without interference with navigation on the Great Lakes or in that portion of the river which is navigable and to maintain the natural function of the river in discharging the great masses of ice which come down from the Great Lakes and to not only maintain, but even enhance, the natural scenic spectacle.

To accomplish this it will be necessary to construct remedial works in the Upper Rapids above the Horeshoe Falls. deflecting to the sides the great mass of water, 25 feet in depth, which is moving by erosion the Horseshoe Falls up stream at the rate of from eight to ten feet per year. This great mass of water tumbling over a small portion of the crest of the Horseshoe adds little to the scenic spectacle except volumes of noise and clouds of spray which screen the real beauty of the Horseshoe from view. The suggested remedial works may be in the form of submerged dams or weirs, or channels cut in the rock river bed, drawing the water from the center toward the shore lines.

These suggested works would make possible the utilization of at least 60 per cent. of the river's flow, which, if divided equally between the United States and Canada and if used under the full difference of level existing in the river from Niagara Falls to Lewiston, would generate 1,800,000 horse power on each side of the river. This power at the present per capita use of electricity would provide for the use of a population of 10,000,000 people.

The Niagara Falls Power Company is now constructing an addition to its generating plant which, when completed, will bring its total combined capacity up to 673,000 horse power. For this extension there is being constructed a new tunnel to carry water from the river above the falls to the edge of the high bank below the falls, at which point it will be carried in penstocks to the new turbines. The intake to the tunnel and the outlet or forebay at its lower end are big jobs in themselves, requiring among other things the construction of a large cofferdam to hold back the waters of the Niagara River. The tunnel will be approximately 36 feet in diameter and will be lined with concrete about two feet in thickness so that its finished interior diameter will be 32 feet.

We are commonly accustomed to associating rock drilling and blasting with mining, quarrying, railroad and highway building, but few of us realize to any adequate extent the amount of rock excavation required in the construction of a hydro-electric project such as this. Here is a job which involves the removal of more rock than has been taken out in a decade of



Interior view of cofferdam around the intake after the water had been pumped out. This shows in detail the arrangement of the Lackawanna steel piling used in building the cofferdam. Two of the centrifugal pumps are shown on platforms on the right.

many of our world-famous mines. It is seldom that a tunnel of this size is driven. Being an unusual job, many methods have been introduced and successfully worked out by the Power company's engineers, as well as by the contractors, Messrs. Read and Coddington.

Compressed air is everywhere available on the job for operating rock drills, drill sharpening machines, hoists, shovels, pumps, and many other appliances. The compressed air is furnished by three batteries of Ingersoll-Rand compressors, each battery consisting of two 200 horse power electrically driven type XB units. A number of older machines can also be placed in use as circumstances require.

Air after-coolers are connected to the discharge of the compressor, and in some cases air reheaters are also used as the engineers fully appreciate both the value of dry air to preserve the lubrication of tools and hot air to obtain the maximum efficiency.

At the present time headings eighteen feet in height and of full width are being driven. This allows steel arch ribs and lagging to be placed as the work progresses. Excavation is carried on by the use of three-fourths-yard caterpillar shovels operated by air, which greatly reduces the cost of handling the broken rock and speeds up operation. The bench will be excavated later.

Unusual work is being done in these top headings. Here three-inch columns made of double extra heavy pipe are used, ranging from ten to eighteen feet in length. After they are set, two, three or four modern Jackhamer drills are clamped on a column and in addition stagings for the men to stand on are also clamped to the same column. In this way the men do not interfere with one another and a much larger surface is exposed for drilling, enabling the use of more machines at the same time. The arrangement just described is shown in the accompanying illustration on page 67.

On an average ten drills are used in each of the four headings and 80 holes averaging ten feet in depth are drilled to a round. In other words, each Jackhamer averages eight holes per shift and seven-eights inch hollow hexagon steel is used throughout the job. Collars and bits are formed by Leyner drill sharpeners. The change in the length of the steel is 24-inches and the bit gauges vary one-eighth inch.

Such work is usually done by the drifter type machine, but Mr. Read and Mr. Coddington have found that the light weight and extreme ruggedness of these small machines, combined with the fact that they may instantly be removed from their cradles and held by hand for drilling the benches, have many advantages over the use of two or more types of machines. Furthermore, they have not overlooked the advantages of having only one kind of drill steel throughout the job, whether the work be drilling in the heading, taking up benches, or breaking up boulders ahead of the shovel. The rock through which this tunnel is being driven is known as Niagara limestone.

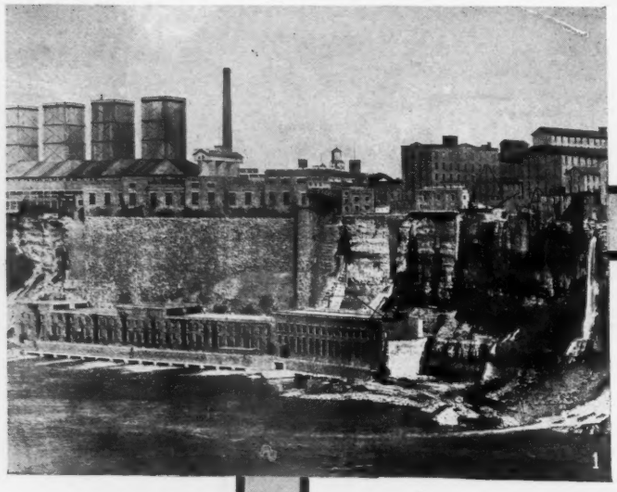
During the day time the headings are drilled and the steel roof supports are placed. The headings are shot between shifts and at night excavation and disposal are carried on. The

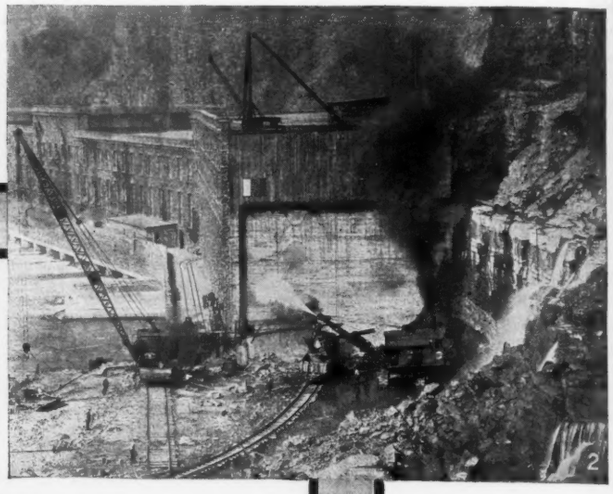
The water being pumped out of the cofferdam.

One of the main top headings showing the unusual method employed. There are four such headings, two being driven from each of the intermediate shafts. The columns vary from eight feet to eighteen feet in length. They are made of double extra heavy three-inch pipe. The Ingersoll Rand "Jackhamers" are mounted in shells or cradles and as many as four drills are mounted at one time on a column. In addition to carrying the drills the columns also support staging upon which the operator stands.

Here is shown another top heading and also drills in operation on the intermediate bench. An unusual feature is the long cross bar on the bench, showing arms to which mounted "Jackhamers" are clamped. The flexible main air hose and the header which distributes the air to the various machines are shown in the foreground. The drill steel will also give an idea of the depth of holes drilled. The pool of water shown gives an idea of the amount of water encountered. All workmen wear hip boots and oil-skin coats and hats. Conditions closely resemble an April shower.

Machines and Operations on the Niagara Falls Project





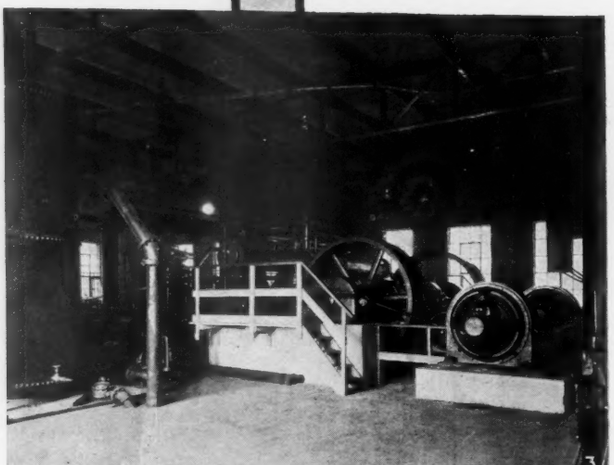


Fig. 1—Shows the Niagara Falls Power Company's plants No. 3 and No. 3 Extension situated in the canyon. Note executive offices on top of the cliff, and in the distance the many mills and factories of every character that dot the landscape of the Niagara Falls district. On the right of the illustration may be seen the discharge from one of the old original tunnels. The rubble exteriors of the buildings harmonize with the general appearance of the country. The retaining wall is fifteen feet at its base and is about 200 feet high. Fig. 2—An excellent view of the existing power plants Nos. 3 and 3 Extension. Here again may be seen the blending of the rubble faced wall with the general scenic aspect. Fig. 3—Two 1190 cu. ft. per minute Ingersoll Rand type XB-2 compressors. There are three such installations on this job. Fig. 4—Leyner No. 50 Drill Steel Sharpener handling Jackhamer steel and shanks; also a Leyner furnace for heating the steel. Fig. 5—Starting the construction of the intake of tunnel. View showing a general inside view of the cofferdam. Fig. 6—Starting the lower end of one of the three penstocks.

shovels load the rock into the four-yard cars which are hauled to the shaft by four-ton electric locomotives. At the shaft the rock is dumped from the car into five-yard pressed steel buckets and hoisted to the top where the material is loaded on trucks and hauled to the disposal ground.

For a short distance and until the headings were far enough apart to enable the electric locomotives and four-yard cars to be placed in it, one-yard mine cars on two-foot gauge tracks were used and these cars were hauled back and forth by "Little Tugger" hoists which were air operated.

The author desires to extend his acknowledgments for the data in the foregoing to Messrs. Read and Coddington, Contractors; Mr. Otto Steigerwalt, Superintendent of tunnels for contractors; Mr. W. A. Haun, Purchasing Agent; and Mr. George S. Anderson, Publicity Director.

METHOD FOR FIGURING FABRIC BELTING

By W. F. SCHAPHORST, M. E.

THE QUESTION is often asked: "How can I figure fabric and Balata belts? I see all kinds of rules for leather belts but I seldom see anything about fabric belts."

In reply I have the following to offer. I have avoided the use of formulas and tables entirely in order to simplify the method as much as possible. Formulas and tables are often very vexing.

Balata Belts

Let us suppose that you want to figure the width of a Balata belt necessary to transmit a given horse power. Proceed this way: Subtract one from the number of plies, multiply by the diameter of the pulley in inches, multiply by the number of revolutions the pulley makes per minute, then multiply by 0.000158 and then divide the result into the horse power to be transmitted. The answer is the width of the belt in inches. If you get 1.8 inches for the answer you will very likely decide on a two-inch belt in order to be safe, which is the right thing to do. If you get 2.01 for an answer you will decide that a two-inch belt will do the work very capably and you will be right because these rules allow for an ample factor of safety. This rule is usable for Balata belts of 3, 4, 5, 6, 7, 8, 9, or 10 ply.

Fabric Belts

Now for fabric belts. The rules as ordinarily given for fabric belts made up in plies are something like this—"A four-ply stitched canvas belt is equivalent to a single leather belt. Eight-ply is equivalent to a double leather belt. And so forth."

Then after knowing the equivalent we have to hunt up our rules of thumb for leather belts before being able to decide on a width necessary for a given drive.

Here is a rule which gives the direct answer without even thinking of leather. The rule applies to most ordinary belts made up in plies such as rubber and stitched canvas. Divide 2640 by the number of plies and to the quotient add 136; then divide the result into the speed of the belt in feet per minute; and then multiply that result by the width of the belt in inches. The answer is the number of horse power that the belt will transmit.

Picturesque view of Niagara Falls. On the left is seen the Canadian Falls and in the center is the famous Horseshoe Falls.

For example, what horse power may be transmitted by a ten-ply canvas belt whose width is six inches and whose speed is 4,000 feet per minute? Substitute in the rule just given above and you will find the answer to be 60 horse power.

To find the width of a stitched canvas or rubber belt, proceed this way: Divide 2640 by the number of plies and add 136 to the result; then multiply by the horse power to be transmitted and then divide by the speed of the belt in feet per minute. The answer is the width in inches.

To find the speed at which a stitched canvas belt may be run, knowing the horse power and width, proceed in this way: Divide 2640 by the number of plies as before and add 136; then multiply by the horse power to be transmitted; and then divide by the width of the belt in inches. The answer is the speed in feet per minute.

To find the number of plies to specify, knowing all other factors, proceed in this way: Multiply the width of the belt in inches by the speed of the belt in feet per minute and divide by the horse power to be transmitted; then subtract from that the number 136; then divide the result into 2640. The answer is the number of plies.

Speed

To find the speed of a belt, knowing the diameter of the pulley and the revolutions per minute—Multiply the diameter of the pulley in inches by 0.262 and the result by the number of revolutions per minute of the pulley. The answer is the speed of the belt in feet per minute.

To find the number of revolutions per minute that will be made by a given pulley, knowing the speed of belt and diameter of pulley, proceed in this way: Multiply the diameter of the pulley in inches by 0.262 and divide the result into the speed of the belt in feet per minute. The answer is the number of revolutions per minute.

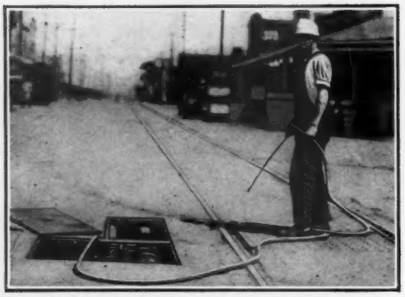
To find the diameter of pulley, knowing the speed of belt and the revolutions per minute, proceed in this way: Multiply the number of revolutions per minute of the pulley by 0.262 and divide the result into the speed of the belt in feet per minute. The answer is the diameter of the pulley in inches.

AERIAL TRANSPORTATION IN HONEY PRODUCTION

Probably few of us have thought of the enormous aggregate amount of energy required to bring together even one pound of honey. Those who have studied the energy necessary to collect it tell us that it takes 62,000 clover blossoms to produce one pound of honey and that it would take one bee 2,750,000 journeys to bring this one pound home. Considering that bees sometimes go a mile or two for honey it will readily be calculated what great mileage is necessary to bring one pound into the state where it is concentrated ready for the bee-keeper to rob the hive and place it on our tables.

CLEANING SWITCHES AND FROGS

THE ELECTRO pneumatic switches on the lines of the Southern Pacific Railroad Company at Oakland, are provided with a connection so that an air hose can be attached and a supply of compressed air obtained for cleaning dirt and dust from the frogs, from between the rails and from the pit in which the switch operating mechanism is housed.



The pit in which the switch operating mechanism is housed.

After the dirt and dust have been completely removed from the pit, oil is placed on the switch operating mechanism, and a stream of compressed air directed against same, cleaning the mechanism.

"BURSTING" TEST SHOWS STRENGTH OF CLOTH

By S. R. WINTERS

THE QUALITY of a fabric, whether it consists of a sample of cloth entering into the construction of a balloon or material for making an apron for the housewife, may be determined by three methods. These are classified as physical, chemical, and microscopic. The first-named is probably the most common test and one extensively applied by the textile section of the National Bureau of Standards. For determining the physical strength of varying kinds of fabrics this Government bureau has recently designed and built a piece of equipment which may be described as a "bursting" apparatus by reason of the application of pressure, to the sample of cloth, to the breaking point.

The specimen of fabric subject to testing is clamped under a ring, with a rubber diaphragm beneath the sample of cloth. The measurements consist of air pressure and deflection at a central point, the measurements being recorded by a common steam indicator. Ultimate results are expressed in terms of surface tension, revealed in pounds per inch. The formula employed is: $S.T. = \frac{P}{4D}(D^2_2 + 34.87)$.

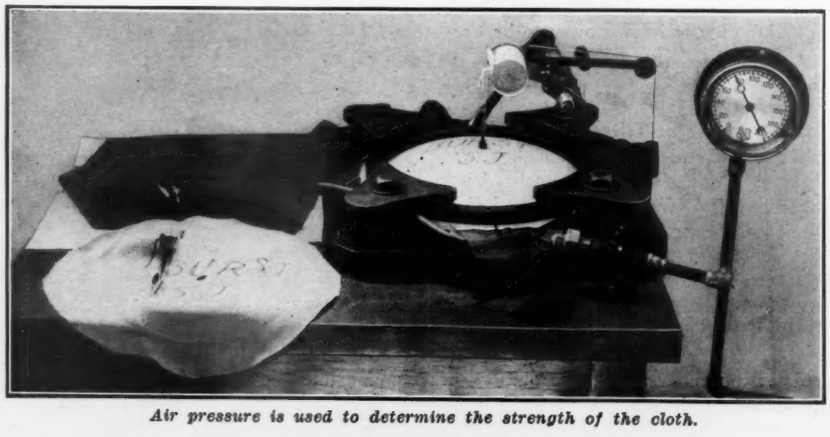
The newly-designed apparatus is useful in denoting the weaker group of yarns in a fabric, as well as indicating the performance of the cloth when placed in service. Equipment for testing the physical strength of fabrics resolves itself into two shapes, circular and rectangular. The latter machine is seven by twenty-seven inches inside dimensions.

A GREAT IRON ORE LABORATORY

A fine building is now in process of erection at Minneapolis to house the mines experiment station of the University of Minnesota, and the North Central experiment station of the United States Bureau of Mines. This is expected to be the finest and best equipped laboratory in the world for the study of iron and manganese ore and will cost approximately $300,000 for the building with an initial expenditure of $20,000 for apparatus. The erection will be 280 feet long and 60 feet wide and the projected equipment will be as follows

High pressure and low pressure steam lines; high pressure air lines and compressor; low pressure air lines and blower; high vacuum lines and pump; low vacuum lines and pump; city water lines; distilled water lines and still; Minneapolis city illuminating gas; three-phase, 220 volt, 60-cycle electric service; single phase, 110 volt, 60-cycle electric service; single phase, 220 volt, 60-cycle electric service; 110 volt, direct current electric service and motor generator set; all of the foregoing connected to all laboratories; four electrically operated cranes; one ten-ton freight elevator; special laboratory benches and tables; special drainage system.

For use in painting Overland bodies, in cleaning and in hoisting and operating air tools of various kinds, the Willys-Overland plant at Toledo is equipped with air compressors with a capacity of 410,000 cubic feet of air each minute. In the company's forge furnaces 275,000,000 cubic feet of gas are consumed each year. The combined boiler capacity of the plant is 7,500 horse power.



Air pressure is used to determine the strength of the cloth.

COUNTING THE DUST PARTICLES IN THE AIR

As described in the *Journal of Industrial Hygiene,* Dr. A. L. Meyer has devised a method for determining the amount of fine dust particles in the air, which is based on the principle that water when brought into intimate contact with air removes the insoluble particles that are in suspension. Dr. Meyer employs a graduated syringe which enables him to measure the quantities of air and water used and in which thorough contact is effected by shaking the two phases. The number of particles taken up by water is estimated microscopically with the aid of oblique illumination and Levy's blood-counter. The average deviation of the number of particles per cubic centimetre of air containing 20,000 to 80,000 particles obtained by this method was not more than + 4000 for 100 cc. and + 2000 for 200 cc. samples.

NEW JENKINS AIR GUN

JENKINS BROS., manufacturers of Jenkins valves, have recently perfected and are now marketing a brass air gun, which is said to be air-tight, and an assurance against costly air waste. The Jenkins renewable disc with which this air gun is fitted, it is stated, is an innovation in equipment of this kind. The disc forms a perfect contact on the seat and takes up the wear of frequent usage. The disc gives long service, but can be easily and quickly renewed, if necessary.

Sectional view of Jenkins air gun, showing renewable disk.

The Jenkins air gun is finding wide use in foundries for blowing off cores, cleaning core boxes, flasks, patterns, and for general dusting. In machine shops for blowing off chip boring filings, trimmings, and for cleaning tools, tops, dies, etc.—and in wood working mills, textile mills, electrical stations, garages —everywhere that a blast of air is required.

The Foundations of the Federal Reserve Bank, is the title of a pamphlet prepared for use at the Annual Meeting of the American Society of Civil Engineers. It gives a detailed description of the caisson work and carrying down the excavation to a depth 86 feet below street level or 62 to 65 feet below water level.

The pamphlet is well illustrated with half tones and lines cuts which show the variety and quantity of equipment required to handle a foundation of this kind. A 10,000 cu. ft. compressor plant, sixteen derricks, two concrete plants, pipe machines, forge shops and reinforcing equipment made it possible to have under air as many as fifteen caissons at one time.

Sending Millions of Air Messages to Countless Homes

The Boon of the Radio Telephone—Supplies the Public with Amusement and Instruction, Including Famous Operatic Selections and Noted Speeches as Well as Information About News Events, Weather Conditions and Even Market Quotations

By ROBERT G. SKERRETT

"HELLO EVERYBODY! This is WJZ speaking: W—J—Z. In five minutes, Sir Hiram Maxim, the famous scientist and inventor, will talk to you."

Punctually, at the time set, hundreds of possessors of wireless telephone sets picked out of the ether the voice of that eminent physicist, and for more than half an hour they were as thrilled as if he were speaking to each of them personally. What is no less wonderful, the people that "listened in" were living as remote as Nova Scotia, possibly abiding way down in Florida, or they had their happy homes located well to the west in Omaha, for instance. And whence do you suppose radiated the waves which carried the spoken word afar? From Newark, New Jersey, where one of our great electrical companies has established a radio broadcasting station for the gratuitous benefit of anyone who wishes to profit by the service. Such is the modern wizardry of the wireless telephone—the mere thought of which would have hastened a person to the stake in the good old days when Salem dealt summarily with those charged with witchcraft.

From WJZ, emanates daily, a programme of audible diversion, instruction, and news. It is necessary for the recipients only to tune their instruments for 360-meter waves, i. e., to shift an index hand to the proper point upon a graduated dial—and then to stand by until the speech, song, or melody is gathered in from space. A child can make the required adjustment; and youth and maturity, within a widespread zone, are now devotees to this latest marvel of electrical engineering. When telegraph and telephone wires are down and roads are impassable, still tidings, cheer, and pleasure are made available to many thousands through this new-born agency of communication. This is one of the heartening aftermaths of the recent urge of armed strife.

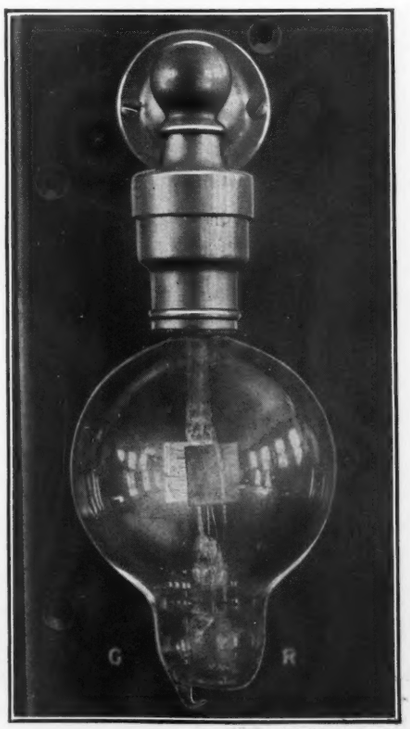
Before we tell more about the functioning of radio-broadcasting station WJZ, let us sketch briefly the evolution of the wireless telephone and get, besides, a popular grasp of some of the phenomena involved in its operation. There is much that cannot be explained; but, even so, human cunning has accomplished wonders in mastering many of the difficulties that have beset the paths of the investigators since the art was in its infancy but a few years back.

Less than a quarter of a century ago—to be exact, in the fall of 1899, a Marconi wireless telegraph apparatus was tested by our naval authorities. A sending station was established at Atlantic Highlands, New Jersey, and the old battleship *Massachusetts* and the armored cruiser *New York* were provided with receiving equipment. The maximum range was 40 miles for the dots and dashes dispatched by means of Hertzian waves; but the officers of the fighting fleet said they would be quite satisfied if they could be assured a service transmitting and receiving range of 25 miles. Today, wireless telegraphy virtually encompasses the globe; and the radio telephone rests fundamentally upon certain phases of this development.

THE RECENT and constantly growing popularity of the Radio Telephone since it has become available to everyone is not by any means owing wholly to its novelty, but rather more to its importance in rendering a very valuable service to the community.

As developed at present it is entirely practicable and any child can make the adjustments necessary to receive the well selected programme sent out daily by the several radio stations already established.

This service bids fair to become an established element in our social routine for obtaining information regarding current events, and supplying entertainment and educational facilities to a multitude of people.



© Paul Thompson

A close-up of the audion as developed a few years back. The distinctive features of the nickel plates and the nickel-wire grid can be seen within the gas-filled globe.

The wireless telegraph is simple in its requirements compared with the needs of the radio telephone. The former calls for groups of waves or continuous waves momentarily modified; and the idea is to produce a single tone at the receiving station either of a short or a longer duration for the purpose of representing dot-and-dash signals. The wireless telephone, on the other hand, must generate, at the dispatching point, a variety of waves, some of which shall have the power of reproducing, at the receiving end, the complex sounds of the sender's voice. In short, in radio telephony we have a duplication of the basic principles active in speech and hearing.

That is to say, although the tone or pitch of the voice may be held monotonously, the maintenance of the keynote does not interfere with the distinctive character of the words. Each speech-sound or syllable is made individual by the hissing, the labial, or the lingual intensity with which the basic voice-sounds are altered. These supertones, as they are called, have patterns or wave-forms of their own, and are supported and transmitted by the robust vibrations—i. e., the sustaining waves, induced by the vocal cords. The ear is acute enough to pick out these speech-patterns and then to pass them on reflexively to the brain for our understanding. And now let us see how mechanical facilities have been evolved capable of functioning as effectively as the organs of hearing and speech and how they have been made to surpass these organs by an enormously increased range of transmission and reception.

It is a matter of common knowledge that technical experts here and there prophesied only a few years back that the wireless telephone would be a commonplace in time, and it is equally fresh in our memories that thousands of others said that such a prediction was little less than an idle dream. To make certain that they were right, these skeptics quoted freely from standard textbooks. In those days, long-distance telephoning even by wire was comparatively limited; it was before the man in New York could "ring up" someone in San Francisco. The invention that made trans-continental telephony commercially practicable has

© Westinghouse Photo.

A group of youthful football enthusiasts getting the radio reports of a big inter-collegiate game.

since proved the indispensable cornerstone of speech by radio.

The stumbling block to long-distance telephoning by wire was the lack of a repeater which could be relied upon to pick up the extremely feeble arriving electrical impulses, give them new strength, and start them afresh upon another lap of their journey. The invention of the audion, a special form of the vacuum tube or incandescent lamp, was found to fill this want; and to Doctor Lee deForest the world is indebted for this wonder-working medium. The story of the audion reveals again how an instrument designed originally for one purpose can be helpfully employed in several ways.

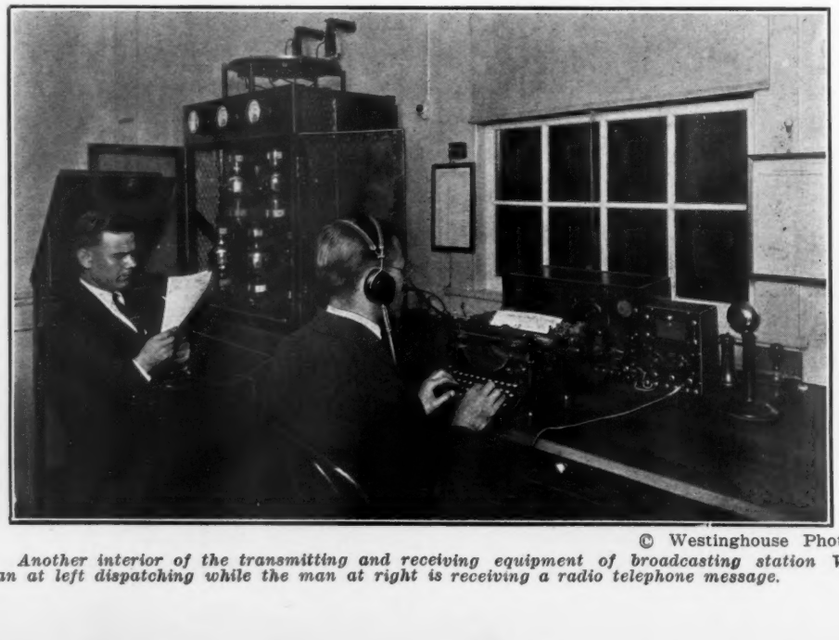
Twenty-two years ago, the men experimenting in the field of wireless telegraphy recognized that the reach of the radio waves sent broadcast probably extended far beyond the zones within which they could be picked up. The problem, therefore, was to discover a new form of receiver of a much more sensitive order, one that would be responsive to signals which were much enfeebled by their longer journeys in space. Doctor deForest was among this group of pioneers, and, happily for the art, he used his eyes and head when existing manuals failed to direct him. During the summer of 1900 he was engaged upon tests in Chicago having for their goal the discovery of an improved detector. One night he had his little apparatus on a table just under a Welsbach burner. He was using what is known as a spark coil to produce radio vibrations or waves. When these waves were generated he noticed, to his surprise, that the flame of the gas lamp flickered or brightened sympathetically.

That action of the incandescent mantel set him to thinking; it suggested to him a new line of inquiry. The whole story of what followed cannot be told here; we shall have to be satisfied with the statement that his work finally led him to a series of tests with a small incandescent light glowing within a globe filled with a suitable gas. From this he evolved what he called his "audion" or amplifying bulb. This apparatus was able to detect very weak arriving radio waves and to strengthen them so that they would be audible to the human ear. Doctor deForest apparently did not appreciate then that his vacuum tube was susceptible of discharging a twofold function: one of picking up greatly enfeebled waves and the other of so building up incoming signals that they could be dispatched anew with their original vigor—i. e., play the part of a repeater. It was the second characteristic of the audion which made trans-continental telephony possible for the first time in 1915. Since then, much has been done to improve the sensitiveness of the audion and to develop this apparatus to a robust form capable of generating voice-waves which can be disseminated for hundreds, yes thousands, of miles. By employing a number of audions, arriving waves can be stepped up so that they attain any desired degree of audibility; or the big brother of the audion, called "oscillion," can be used to broadcast from the overhead wires or antenna of a radio station electrical speech-waves suitable for long-distance wireless telephony.

For the sake of those interested in some of the technical aspects of the art of radio telephony, perhaps a popular description of the basic features of the audion would not be out of place here. The lamp contains three essential elements: a filament, two small nickel plates, and a thin nickel wire bent in the form of a series of loops and termed a "grid." As Doctor deForest has explained: "The incoming current, to be repeated and amplified, is conducted to the grid wire. The outgoing line is connected, one terminal to the plates, the other to the filament. In this circuit is found a battery. A separate battery lights the filament to incandescence. The heated gas then becomes a conductor of the local current from the battery, and allows this current to pass from the cold plates to the hot filament."

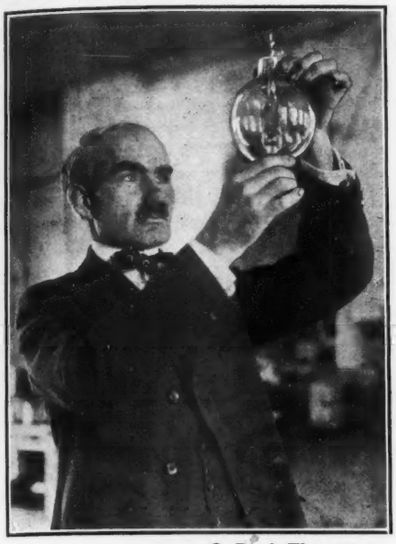
That is to say, ordinarily there is an electrical gap between the cold plates and the filament, i. e., the circuit is broken. But the moment the filament is raised to incandescence it heats the surrounding gas, and the tiny ions of that gas become carriers of electrical charges and, by their movement from the filament to the plates, they invisibly close the circuit so that the current from the local battery has a path along which it can flow. These ions, in speeding from the filament to the plates, pass between the loops of the grid, and as the voice-waves of the arriving radio message reach the grid they set up disturbances which affect, according to their character, the steady stream of the ions. Just as these changes are caused in the tide of the ions so are they repeated at the nickel plates, and the current from the local battery responds accordingly.

As a result of these several phenomena, the locally produced sympathetic waves are identical in form but bigger, and therefore much stronger than the weak arriving waves which they replace. In other words, they are like fresh relay runners, and they start off on the new lap in the race with vigor. Such, broadly, is the manner in which the audion does its work whether as a repeater in long-distance telephony by wire or as a detector and amplifier in wireless telephony. Many men and many



© Westinghouse Photo.

Another interior of the transmitting and receiving equipment of broadcasting station WJZ. Man at left dispatching while the man at right is receiving a radio telephone message.



© Paul Thompson

Doctor Lee deForest examining one of his audions. Vacuum tubes of this type were used in 1915 to communicate by wireless telephone from Arlington, Virginia, to Hawaii and to Paris.

minds have helped to enlarge or to improve the capabilities of the audion and the oscillion since deForest conceived them; and radio-broadcasting station WJZ gives continual evidence of the fruit of these cumulative labors. Right here, however, it should be understood that two types of waves are required in broadcasting service. One set of waves constitutes the transmitting foundation, and are called "carrier waves"; these are of very high frequency and are able to span great gaps in the ether. Upon these waves are laid, so to speak, the speech-waves which, otherwise, could not travel anything like so far.

Perhaps we can get a picturesque conception of this association of waves if we consider the heaving bosom of the open sea. The big billows roll onward, and upon their massive slopes we see other lesser waves, yet neither of these undulations seem to interfere with the other: the fundamental waves sweep forward unperturbed by their burdens.

Now the human ear can differentiate sounds up to a maximum of 5,000 vibrations a second: above this audibility ceases so far as unaided hearing is concerned. But there are sound-waves of infinitely shorter length or higher frequency which can be detected by the apparatus already described; and electrically these are audible, if we may so use the word, up to 6,000,000 vibrations a second. Each of these humanly inaudible sounds has its own peculiar wave-form and will affect characteristically a suitable microphonic or amplifying receiver. These minute waves cannot travel alone for any distance, but if laid upon the sturdier or bigger wireless waves they will then go as far as the latter. While the basic radio waves suffer decay or diminution as they advance, it is a curious fact that the superposed speech-waves or sound-waves are not impaired to anything like the same degree during transit. Therefore, these infant sound ripples journey broadcast on the backs of the giant wireless undulations.

By the utilization of these two sorts of waves the radio engineer has both the groundwork and a perfect superstructure for a commercial system of wireless telephony. He has not only the power to bring widely separated points into communication but he has means at his command which will insure privacy or selectivity. The difference between the perceptive capacity of the human ear and the electrical ear, so to speak, with its ability to discriminate within a range up to 6,000,000 vibrations a second, renders it practicable to "tune" receiving instruments to waves of certain lengths and thus to make the apparatus deaf to other waves, even though many stations may be sending simultaneously.

While developments in vacuum tubes enabled experimenters in 1915 to dispatch voice-waves from Washington, D. C., both to Paris and to Honolulu, the wireless telephone as we know it in the home now is directly the outcome of work done by us, during our participation in the World War, to equip our airplanes with apparatus which would permit vocal communication when aloft. Before the outbreak of that conflict, vacuum tubes had been turned out at a rate of not more than a few hundred a week; and yet when the armistice was signed a single factory was manufacturing fully 25,000 of these tubes every seven days. This was only one phase of the diversified requirements then being met by several of our great electrical concerns in fabricating wireless-telephone sets for the army and the fighting fleet.

The military authorities were quick to recognize that the radio telephone was more desirable than wireless telegraph, because the latter, to be effective between the ground and the flyer, necessitated a knowledge on the part of the aviator of a telegraph code. The pressure of service imposed that this code should embrace but a few signals, and these were limited in the main to directing the gunfire of ground batteries or to reporting upon the action and position of the foe's artillery. It was clear to those interested, that much might be gained offensively and defensively if communication could be maintained vocally between the ground and the aviators, and likewise between the

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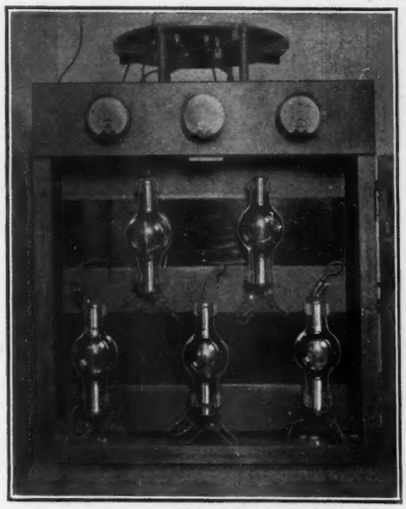
Lydia Lipkovska, court singer to the late Czar of Russia, singing into the transmitter of the radio telephone.



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An interior view of the transmitting set of station WJZ. Two of these vacuum tubes serve as oscillators for the generation of high-frequency carrier-waves, and the remaining three act as modulators and lay upon the carrier-waves the voice or music waves.

flight commander and the pilots of his squadron. Instead of an abridged code, communication would have the full range of spoken intercourse.

The war came to an end too soon to offer wide employment to airplane radio-telephone sets; but in June of 1918, so it is said, a squadron of 39 flying machines was controlled in the air by voice command. Before hostilities ceased, thousands of flights were carried out and the machines were manoeuvred in formations that would have been out of the question but for the orders transmitted and received by radio telephone. The point of present interest is that the research work done and the obstacles overcome—some of them staggering in their nature—left the contributing electrical companies in an especially favorable position to put their experience and facilities to peace time application.

The Westinghouse Electric and Manufacturing Company, which had done its full share in fabricating airplane radio apparatus, has called into being successively four broadcasting stations located at Pittsburgh, Pa., Newark, N. J., Springfield, Mass., and Chicago, Ill. Pittsburgh, (KDKA), operates on 330-meter waves; Newark, (WJZ), uses 360-meter waves; Springfield, (WBZ), is distinguished by 375-meter waves; and Chicago, (KYW), is far enough away from Newark to transmit on 360-meter waves without causing interference. From these distributing stations there is placed freely at the disposal of tens of millions of persons daily a service that is unique and unequalled elsewhere the world over. While the primary purpose is to cater to the populace lying within a radius of 100 miles from each broadcasting center, still, as a matter of fact, others living many hundreds of miles away may be able to "listen in"—depending upon atmospheric conditions and the type or capacity of their receiving apparatus.

Despite what has already been told about the essential elements of a radio-telephone sending or receiving outfit, there is something mys-

© Westinghouse Photo.

Putting the farmer in touch with the world.

terious and awe-inspiring in the results obtained by an antenna, a few score feet long, linked with an inconspicuous-looking box. In its simplest form, relying upon a crystal detector to catch the sound-waves as they come through space, the apparatus will pick up waves ranging in length from 190 to 500 meters. A tube set, i. e., one equipped with audions for the finer detection and the greater amplification of arriving waves, will permit of tuning to radio waves ranging from 180 to 700 meters in length; and this same outfit by adding to it a loading coil, can receive signals dispatched on waves of from 1600 to 2800 meters in length. A tube set, by the way, is a thousand times more sensitive than one depending upon a crystal detector; and it is likewise susceptible of nicer adjustment in shutting out waves that otherwise might interfere with the clearness of the desired ether impulses. On a clear, cold night, a tube set should catch messages or music broadcasted by radio that may have journeyed through space a full 5,000 miles. It is self-evident that trans-oceanic wireless telephony is nearly here; and plans are rapidly formulating that will make it a commercial fact ere long.

Now let us suppose that the reader has just purchased one of the outfits described and has adjusted it to be responsive to the 360-meter waves broadcasted by WJZ at Newark. Here is a sample of a concert program—chosen at random from many—that can be heard in the course of a week between 8:20 and 9:15 p. m.:

Monday—Operatic selections;
Tuesday—Popular music;
Wednesday—Miss L. Madden, soprano, in person;
Thursday—Popular music;
Friday—Signor Cavalinni, tenor of the Scotti Opera Company, in person;
Saturday—Dance music;
Sunday—Sacred music.

Other features broadcasted during the same week were: general news service daily at 7.55 p. m.; weekday hourly news service, on the hour, from 10:00 a. m. to 6:00 p. m.; official Government weather forecast, three times daily, at 10:55 a. m., 3:55 and 10:03 p. m.; marine news, weekdays, at 2:05 p. m., except Saturdays; and official Arlington time announcement daily at 9:55 p. m. Further, every Thursday, at 7 p. m., some well-known person lectures for half an hour upon his chosen line of work; and on Tuesday and Friday nights, at 7 p. m., known as children's hour, youthful auditors are entertained with fairy tales and other imaginative stories. Latterly, sermons have been broadcasted in a similar manner; and this has enabled WJZ and its companion stations to carry the church right into the home or to preach to pastorless congregations.

Anyone familiar with farm life, for example, appreciates how isolated it may be at times; and the radio telephone offers one way by which to bridge the distance that lies between the rural districts and places of entertainment and sources of news. Not only that, the farmers touch with current events is frequently not a close one because his paper does not always reach him from day to day, and much may happen in the meantime of immediate concern to him. Whether he be bent upon buying or selling, knowledge of the day's prices may make all the difference between profit or loss.

Again, he knows from experience how suddenly the weather may change, and to be informed about atmospheric conditions three times a day may give him the needful warning to guard against a chilling frost or to prepare for an oncoming storm that has altered its course abruptly. Arrangements have now been made with several agricultural journals whose radio editors will gather every day such news as will be of interest to their readers, and these items will be duly broadcasted by radio telephone. If the farmer lacks a receiving set he may still profit by the service through one owned by a neighbor; and just fancy what the village store might mean if the proprietor were shrewd enough to provide his establishment with a receiving set equipped with loud-speaking attachments!

The woman in the rural or suburban home, invalids, and "shut-ins" generally, can have the monotony of their day broken by the hourly dissemination of news; and then there is the assurance of a whole evening's diversion, no matter what may be conditions without. Indeed, if from any cause, the accustomed paper is not delivered at nightfall, still the outstanding features of the afternoon's news will arrive through the ether. In fact, supplemental news—events occurring after the evening paper has gone to press, is now dispatched by wireless up to the closing hour of the radio-phone stations. Latterly, distributing center KYW, in Chicago, has broadcasted nightly the whole of each evening's performance of grand opera! And the same practice will be instituted in New York City. Think of it, amid the dreadful din and discords of war were born agencies capable of spreading afar to monster audiences the melodies of the masters of harmony.

It is only a matter of time—probably in the near future, when arrangements will be made with the Government so that broadcasting stations placed at strategic points throughout the length and breadth of the land will operate continuously for eighteen hours daily. Surely, this is a thrilling prospect and a promise that no one anywhere within our borders need be isolated from the rest of the world.

© Gaumont Company

A squadron of army airplanes manoeuvring by voice commands delivered by wireless telephone from the White House grounds in 1919. A special demonstration for the president.

In truth, we are only at the threshold of radio-telephone potentialities. Already, the U. S. Public Health Service has inaugurated bi-weekly wireless telephone health talks, and this is a mere hint of how radio may be used for educational purposes.

The public at large has no idea of the way in which radio-phone receiving sets are multiplying. There are to-day fully 40 large concerns engaged in the manufacture of this type of wireless apparatus; and the demand has increased tremendously within the last few months. Many persons buy certain essential parts and assemble them at home, and others are sufficiently resourceful to make nearly all of their outfits. It is authoritatively stated that within the area lying east of the Mississippi River and north of Washington, D, C., there are quite 150,000 private receiving sets within the range of station WJZ at Newark, New Jersey, and each instrument may be the means of entertaining or edifying anywhere from one to scores of listeners.

Lest this article have misled the reader into believing that all is plain sailing after acquiring and installing a radio-receiving set, a word of caution should not be out of place here. A particularly fickle atmospheric bugaboo is likely to upset his plans for amusement time and again—this is what is technically termed "static," and broadly covers divers conditions within the enveloping air. The sun, the aurora borealis, moisture, variations of temperature, and electricity lurking in the clouds may severally or more or less in combination mar the ether's capacity to transmit radio waves. Even so, there will be many other periods within which satisfactory or perhaps extremely surprising results may be obtained when the receiving instrument is properly attuned. One has only to adjust his apparatus to pick out from the ambient universe, so to speak, any of a wide range of waves radiating through space, and thus to put himself in touch either with a perfect stranger or with a familiar station. Can any one deny that this is marvelous—yes, mysterious?

Who can rightly say that wireless telephony would not be something for the future to reveal had Doctor deForest failed to heed the flutterings of his Welsbach light 22 years ago? Some people would have blamed the gas company, offhand, but he was alert enough to realize that his electrical experiments were responsible, and in the changing flame he read signals which started him upon his epoch-making inventions.

AIR AND WATER PRESSURES

ACCORDING to the U. S. Geological Survey, the difference in altitude between the highest and the lowest points of land in the United States is 14,777 feet. Mount Whitney is 14,501 feet above sea level, and in Death Valley there is a depression 276 feet below sea level. The normal absolute atmospheric pressures at these altitudes would be, respectively, 8.7 and 14.8 lb., a difference of 6.1 lb.

The greatest depth yet found in any ocean is 32,088 feet at a point about 40 miles north of the island of Mindanao in the Philippines. The water pressure at this depth would be very nearly seven tons per square inch.

"Little Tugger" air hoist rigged up to operate belt conveyer.

KILLING INSECTS BY USE OF COMPRESSED AIR

By S. R. WINTERS

THE LUSCIOUS grapes or other small fruits which you purchase at the delicatessen shop may owe their soundness and fine flavor to the use of compressed air, as far-fetched as the application may seem. For, thanks to mechanical ingenuity, a compressed-air pump has been designed whereby liquid poison may be sprayed on vineyards and orchards in order to rid the growth of insects and fungous enemies. This method of eradicating pests infesting fruits has the approval of the Bureau of Entomology, U. S. Dept. of Agriculture.

The compressed-air pump is made of brass or galvanized sheet steel, the capacity of the apparatus ranging from three to four gallons. Agitation of the deadly liquid insecticide is effected by entrance of the air at the bottom of the tank. Once the watery poison to be sprayed on the vineyards or orchards is poured into the tank and the opening closed by an air-tight cap, the air is pumped until the spray material is under adequate pressure. The tank may be emptied by three or four pumpings of a dozen strokes each. This type of compressed-air sprayer is conveyed about the vineyard or orchard by one person, the outfit being suspended from the shoulders by a strap.

Another type of equipment designed to eradicate insects from grapes and other small fruits is more elaborate than the one just described, being referred to as a barrel hand-pump outfit. It is capable of containing 50 gallons of liquid poison, and the outfit lends itself readily to the spraying of home orchard, small vineyard, and fruit garden. The pump is equipped with an efficient agitator, either of the paddle or rotary design. Sufficient pressure and the subsequent uniform discharge of the insecticide is guaranteed by providing the pump with an ample air chamber to which a pressure gage can be attached to advantage. The pump can be mounted either on the head or side.

AIR HOIST OPERATES BELT CONVEYER

THE ACCOMPANYING illustration shows a novel adaptation of a small compressed air operated hoist at one of the Cerro de Pasco Copper Corporation's ore dumps.

The ore dump shown in the print was let out by contract. The contractor wanted to increase his earnings so instead of loading the ore cars by hand he rigged up the launder and truss and connected up a "Little Tugger" hoist as shown.

The launder is mounted on two cast wheels and can be moved very easily to suit dumping or loading conditions. The "Tugger" is mounted on a steel plate riveted to the launder, six feet from the dumping end. The drum of the hoist is "lagged" or wrapped with one and one-half inch rope increasing its diameter. A six inch leather belt connects the hoist to the nine inch diameter driven pulley on the launder. The conveyer belt travels at a speed of 78 feet per minute which permits the loading of fifteen tons of ore, a heavy course sulphide, per hour. This is the overall time and includes time of shifting launder, etc.

ELECTRIFICATION OF SWISS FEDERAL RAILWAYS

Fifty-seven million francs have been credited in the Swiss budget of 1922 for electrification of the Federal railways, according to a report to the Department of Commerce from Consul Haynes at Berne. It is hoped that the electrification of the Bellinzona-Lugano-Chiasso, the Erstfeld-Lucerne, and the Goldau-Zug lines will shortly be completed. The Amsteg power station, of 80,000 horsepower, will be ready to furnish energy about April, 1922, and the Lucerne-Zug-Zurich line will probably be electrified by the end of the year. Together with the St. Gothard, the Sion-Lausanne line is to be electrified, and will be opened in the summer of 1923. The current will be supplied by the 60,000 horsepower Barberine station.

HIGHWAY REPAIR TRUCK USES AIR DEVICES

By C. W. Geiger

THE BOARD OF Supervisors of Kern County, California, has recently placed a specially designed highway maintenance truck in operation which uses compressed air for a great variety of purposes.

Air is used for stenciling traffic or ordinance signs on streets, or highways, using special steel stencils made for that purpose, with a paint spray oufit. Compressed air is also used in painting and whitewashing fences. A five gallon paint tank on wheels is provided for this purpose together with 100 feet of hose.

Compressed air is used in spraying trees and shrubbery in parks, streets and along highways, using a water tank of 150 gallons capacity, filled with fungicide, and high pressure fog guns with air hose.

Compressed air is also used in putting out fires along highways, especially grain fires which burn down fencing by means of a tank filled with chemical under high pressure. The speed of this portable unit in overgear makes it practicable as an auxiliary fire-fighting apparatus. The truck carries a pneumatic post hole digger for use when erecting fences along highways or when putting up county or traffic signs.

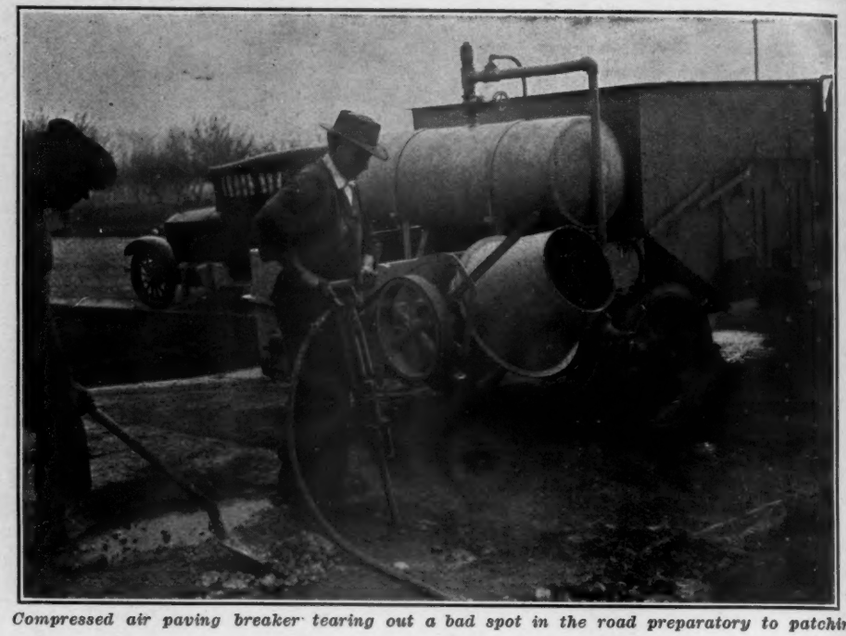
The truck carries a large pneumatic hammer, with assorted chisels, tampers, etc., for cutting out paving when excavating for sewer pipes, underground conduits, etc. Excavations refilling can also be properly tamped by tools provided. Pneumatic hammers are also used in breaking up damaged places in the road when making repairs on concrete, macadam or other forms of paving. An air jet serves to blow out refuse. A chipping gun is used in chipping out cracks on concrete highways before filling in with new material. The compressed air will also be used in removing old paint, rust, etc., from steel work by means of a sand blast outfit. Repainting will be done with paint spray equipment.

On the rear of the truck is a tar or road oil heating tank equipped with gas burners. A syphon nozzle and hose are provided for spraying hot tar or oil under air pressure.

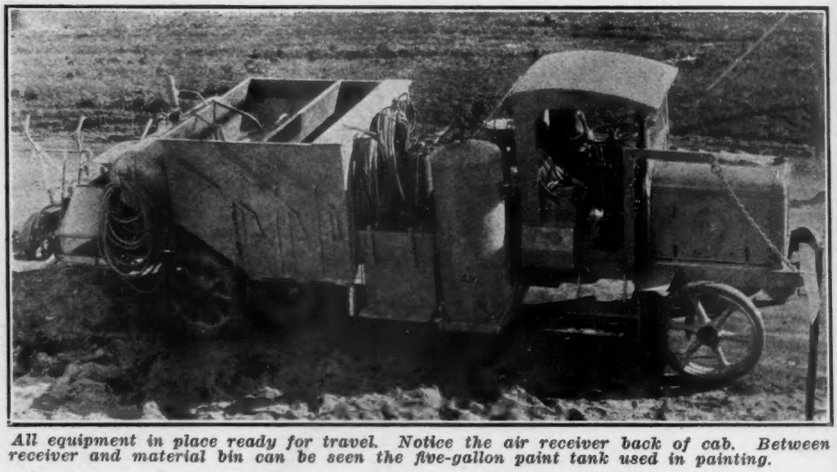
The 150 gallon water tank can be filled by means of a centrifugal pump, with self priming device and suction hose, by pumping from wells rivers, etc. The contents of this tank can be withdrawn by gravity or compressed air can be introduced and the water forced out under pressure.

The air compressor is operated by a belt from the forward drive shaft, and has a capacity of 80 cubic feet per minute. There is a large air receiver on the right side of the truck just back of the cab, provided with safety valve, gage and hose connections, for maintaining a pressure up to 200 lbs.

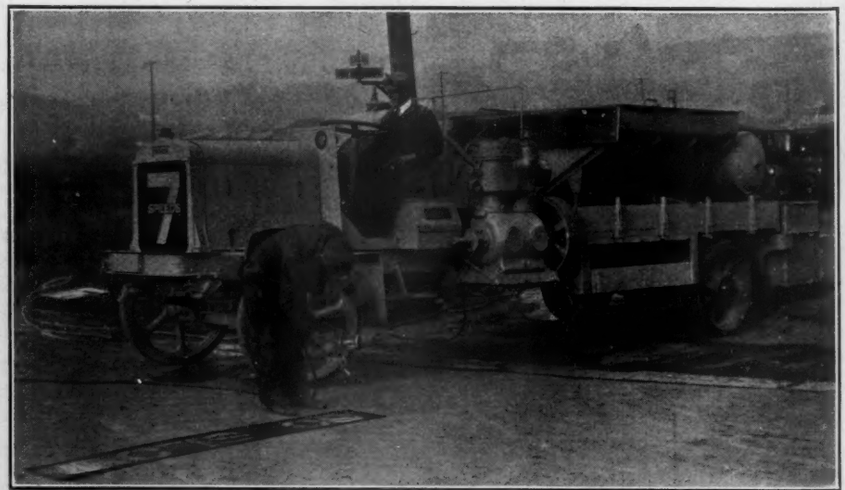
The truck also carries a rotary concrete mixer driven by an auxiliary shaft from the transmission, and combination material bins, with a capacity of 1,000 pounds of cement, one cubic yard of sand, and two cubic yards of gravel or rock. In addition there is a large variety of other equipment carried.



Compressed air paving breaker tearing out a bad spot in the road preparatory to patching.



All equipment in place ready for travel. Notice the air receiver back of cab. Between the air receiver and material bin can be seen the five-gallon paint tank used in painting.



Traffic signs are stenciled on the highway, using a paint spray and steel stencils.

Recollections of the Early Days of the Panama Canal

Recently Proposed Development of American Waterways Recalls Interesting Incidents Connected with the Building of the Famous Panama Inter-Ocean Route

By W. L. SAUNDERS

THE CONSTRUCTION of large engineering enterprises when undertaken by the Federal Government always brings into sharp relief the relations existing between our legislators who control the purse strings and those who are actually in charge of directing operations in the field.

The author, Mr. W. L. Saunders, President of Compressed Air Magazine Co., was intimately associated with the chief characters connected with the building of the Panama canal and he recounts in this article a number of amusing but no less instructive experiences, including an alligator hunt in which he participated while on the canal.

A FEW YEARS after the United States took over the Panama Canal from the French, a party of Congressmen, headed by Serano Payne and John Dalzell, visited the Isthmus in order to familiarize themselves with conditions there.

Large appropriations had been made and bills for more money were pending. There was a great deal of criticism of the work in the magazines and newspapers. Advocates of a sea level canal led by the volatile and unextinguishable Mr. Bunau-Varilla were making headway against the plans of the Government. Roosevelt was President, and to his everlasting credit it should be said that he, a civilian, reversed the majority opinion of an international board of engineers who had recommended a sea level canal. In this he also reversed himself, for he had previously stood for the sea level plan when Mr. John F. Wallace, his chief engineer, endorsed it.

Looking backward we now see the wisdom of the lock canal advocates. It is doubtful that a sea level canal could have been finished up to the present time. Some doubt that it could have been finished at all in view of the experience with slides at Culebra, which might have increased a hundred-fold had the excavation been pursued 85 feet deeper. In any case, the cost, in the words of General Goethals, might have reached a thousand million dollars. The total cost of the present canal is about 400 millions, including the purchase of the French concession and the Canal Zone.

I happened to be on the Isthmus when the Congressmen arrived—about 50 in number—and was graciously invited to join the party. They were received with much deference and interest by the Panamanians and by the working force on the canal. John F. Stevens was still on the job as chief engineer, though he had just sent in his resignation, as to the reasons for which there was much speculation in the United States. Stevens is a typical engineer, a man of much ability, direct and unequivocating in all things. Really this man has received too little credit for what he did at Panama. He favored the lock system, he drew the plans on the basis of which the canal was built, and he reconstructed the old Panama Railroad.

John F. had little respect for congressional intelligence. He did not meet this august body until they found him with his coat off somewhere down in the Culebra Cut. As he and I strolled about together he asked me what "these fellows" were down there for.

"To get information about this great engineering enterprise," I replied.

"Well," said he, "they will know less about it when they get through than before they came."

I told him there was so much speculation in the States about his reasons for resigning and that I hoped he would soon make a statement on the subject. Looking with his blue eyes straight at me, and at close range, the big engineer, with a twinkle in his eye said:

"You got plenty of reasons from Wallace, didn't you (Wallace was criticised even denounced as unpatriotic by Secretary of War Taft and the newspapers), and look what he got for it. Have you heard the story of the Chinaman who was taken on a toboggan slide. Down, down the hill he went, now striking one side of the bank and then the other, faster and faster he went till they reached the bottom, when everybody was upset and rolled over the ground a hundred feet.

As he was picking himself up one of the party said, 'Come on Ching, let's take another.' 'Not by a damned sight,' said the Chinaman."

Stevens ignored the congressional party, going about his work and showing a bored look when one of them sought him out and questioned him. One day, as our train in the big cut was stalled for some time, several of us got off and going to the chief engineer asked how much longer the train would be delayed.

"We have a rule on this work," he said, "which is invariable. The right of way is given first to the gravel train, next to regular passenger trains, and last to distinguished visitors."

"Who is that gentleman," some one asked Stevens,—"the one leaning up against the car?"

"That isn't a gentleman," was the quick response, "that's a Congressman."

John F. Stevens resigned his chief engineership because Jim Hill of the Great Northern Railroad wanted him to take an important and high salaried position in a new railway enterprise in the West. But things did not go well, the project fell through, and Stevens later on turned up in New York, where he organized a contracting firm which became involved in serious financial difficulties.

Engineers usually do not make successful contractors. Stevens with all his ability was not an exception. I met him on the street in New York after the Canal had been finished. Goethals was the popular lion—Stevens made the plans, and had he stuck to the job the glory would have been his, but now, alas, he had lost his opportunity and all the money he had.

This latter he admitted to me, yet his eye was of the same true blue, the twinkle was still there. His courage was not broken. He went to Russia after the War broke out, did splendid work, as in fact he always did. His star began to rise again, when Bolshevism overtook him and brought disaster.

At the Tivoli Hotel on the Pacific side I sat at table with a very nice fellow, who told me that he represented a district in Missouri. After three or four days of inspection, we were smoking our after-dinner cigars together, when he said to me.

"I have been greatly impressed by this work. We came here expecting to see a bog, a swamp. I thought we were spending Government money foolishly, that the canal was impossible. Everything looks fine to me; the work seems to be going along well; but something must be wrong about it, and I can't find out what it is. I am a lawyer and from Missouri. You are an engineer and I should like you to tell me in confidence what the real trouble is."

I tried to assure him that everything was all right; but he was still suspicious.

"Why," said he, "first Wallace resigns, now Stevens is leaving, surely these men would not give up so big a job if something was not wrong."

"Oh," I said, "they leave to take positions at more salary."

"More salary!" he exclaimed, "why, my dear Mr. Saunders, don't you suppose that I could make more money practising law than I get by going to Congress? I tell you that the man who stays on this job and finishes this canal as chief engineer will be as big a man as a Congressman."

Later, after the completion of the canal, I had the pleasure of telling this story to General Goethals, who said that this almost induced him to return his medals.

One evening at the Tivoli some one suggested an alligator hunt. We were told that all about the Canal Zone the big alligators had

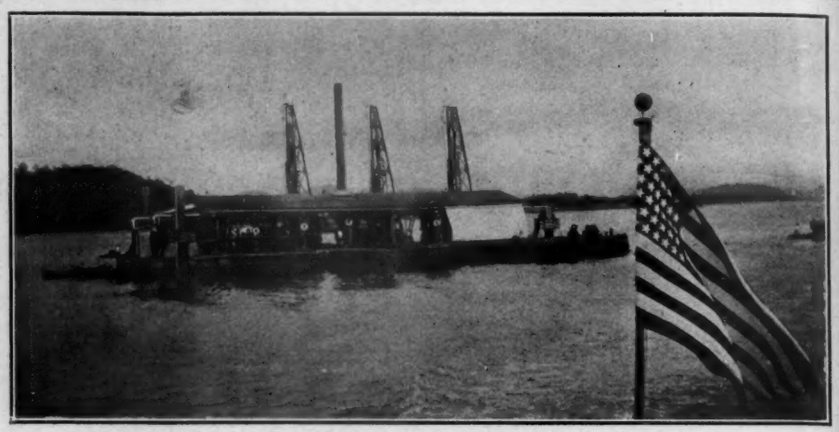
been killed off or driven away, but that there was a place about twenty miles south on the Pacific where there might be some real sport. We enlisted Captain Shanton in our scheme. Now, Captain Shanton was Chief of Police on the Zone. He had been one of Roosevelt's rough riders in the Spanish War,—a fine big fellow, the kind one reads about in books. He looked like the hero lover in a play, the man who wins the girl by twisting the neck of the villain. Shanton picked his party, taking only men who could shoot. Burleson, of Texas, afterwards Postmaster General, was in the bunch. It happily fell to my lot to get an enlistment.

Early one morning, equipped with Winchesters, our little party of hunters started down the Pacific Ocean.

"The ship drove fast,
Loud roared the blast,
As southward, aye, we sped."

Our boat was a steam launch, almost a yacht. It had been built by the French, strange to say, on the top of the Culebra hills, far from the sea. The presumption is that the plans of the French engineers involved flooding and damming the Culebra Cut, taking out most of the rock by submarine blasting. This would have been a very expensive and slow method of excavation.

We entered the mouth of the Chorrera River, a veritable river of doubt, for not one of the party had ever heard of it before. At its mouth this river is almost as wide as the Delaware at Trenton. On either side we saw at times little bamboo huts of the native dark Indians. As we sped further up stream there



Passing the drill boat at the entrance to the Canal.

was no sign of life, except the chirping of birds. The strength of the current increased as the width of the stream grew narrower.

At a point about eight miles from the mouth we cast anchor and took to the small boats, three people to a boat, a negro oarsman in the center, while a man with gun cocked stood at the prow and another at the stern. Shanton told us that we should reach an abrupt bend in the stream, a place where the river widened, with sloping sand banks on which we might expect to see alligators asleep, basking in the sun.

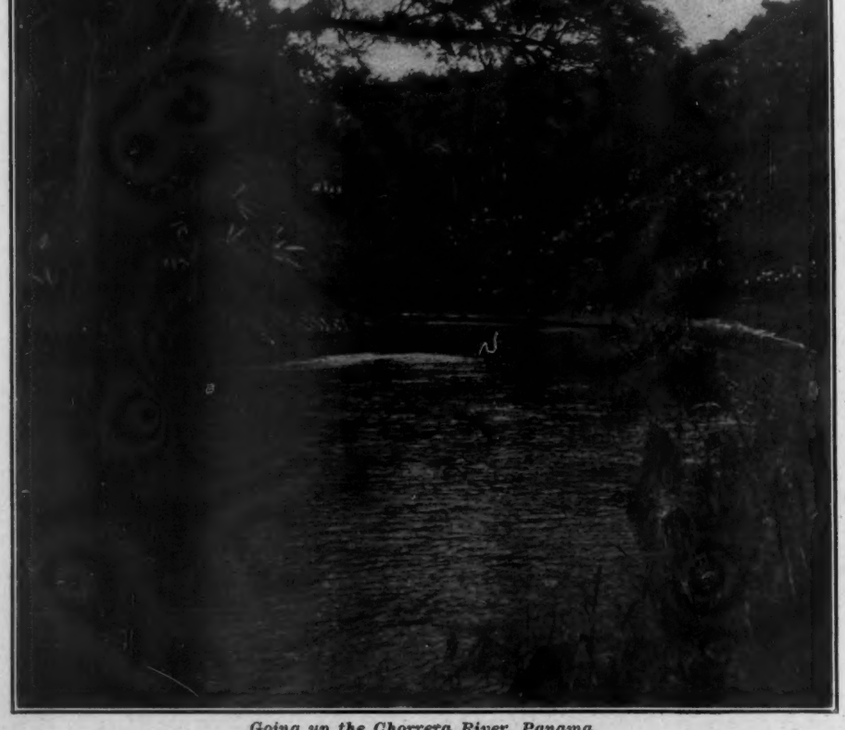
We saw them all right, about 50 in a bunch, some of them fifteen feet long. Our rifles poured forth salvos for two or three minutes; but we were at long range. The sleepy saurians were now as lusty as young elk, for they scampered into the water, coming up for air all around our boats, at times within a few feet of us. For twenty minutes we played sharp shooters, firing at each head as it bobbed up. One Congressman from the West, who had never seen an alligator before, found himself in a light boat in the midst of two big fellows who had evidently been badly wounded, for their tails, legs and open mouths would spring up from the muddy stream as if the beasts were trying to get at their tormentors.

This honorable gentleman demanded that the oarsman "get out of this." The old negro, having no fear of gaitors, only grinned. "Get out of this, I tell you. If you don't I'll use my gun on you," suiting the action to the word. Sam pulled for the shore now more afraid of a Congressman than he had ever been of alligators.

We landed a few, one measured ten feet, six inches. Many, Shanton told us, were wounded and drowned. Strange as it may seem, an alligator when badly wounded keeps under the water and drowns,—at least Captain Shanton gave us that comforting thought perhaps to offset some bad marksmanship.

It is popularly supposed that the way to kill an alligator in the water is to hit him in the eye. Well, just try it, and see what sport the beast will have at your expense. It is harder than the proverbial camel going through the eye of a needle. An alligator's eye at a distance is a bull's eye to the marksman, which looks about the size of the eye of a bird. Besides one might put out the eye without doing any more damage than to curtail the sight of the quarry. The vulnerable spot is the body. Alligators should be shot in the shoulder, just at either side of the head. A dead one which we pulled up on the bank had an old score on the top of his head about the size of one's thumb—the relic of a shot fired perhaps a thousand years ago (that is, it might have been provided Indians then had guns—surely the gaitor looked old enough).

Alligators are water animals. They breathe the air, and can take a long breath. They spend half their time on land and half in the water. They are as sly as a fox, playing possum in search of prey or in the face of danger. They hibernate in winter, going up into the marshes and burying themselves during the cold season, apparently without food. When out shooting for marsh hens I have stumbled

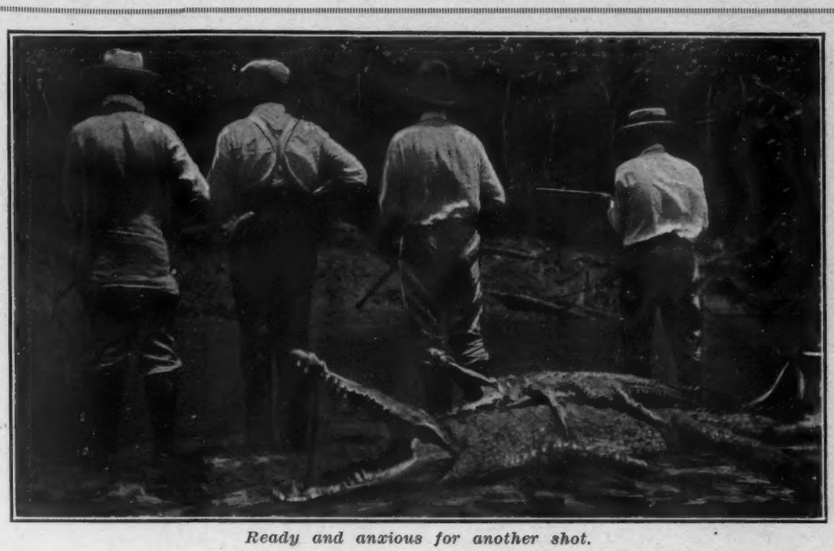


Going up the Chorrera River, Panama.

over what I thought was a log. It was as still as death, covered with grime, and only by much poking was the alligator revealed. They have been known to lie perfectly still when discovered in this condition, and as soon as the people about were not looking, or had moved away a little distance, the alligator would spring into the water and disappear. The question is often asked, what does an alligator feed on? They eat anything—birds, animals and fish. Various animals will come down to the edge of the stream to drink. The alligator approaches quietly until within a short distance from the shore, when he gives a sudden spring, taking the animal in his mouth and going under with him, drowns his prey. He then takes it on shore, leaving it sometimes for several days covered with leaves or brush, until decomposition sets in, in which condition he considers it more palatable.

The head of the alligator is by nature camouflaged to look like a log or something floating in the water. The eyes are on top and project upwards. Swimming is easy because of the enlarged body, which just balances the weight of the water, so that he really floats, with nothing on the surface but the top of his head. When swimming there is no ripple or movement of the water to reveal his presence.

It has always been a question whether or not alligators would attack human beings. They are really very timid, and I doubt that there is any well recorded instance of an alligator attacking a white man. They will attack colored people and dogs. Negroes are very much afraid of them and will not bathe while they are about. As a boy in Florida I frequently bathed in rivers filled with alligators, but we always kept watch from the surface, one boy being on shore while the others were in the water. The alligators would approach within a few hundred feet of us, with their noses pointed toward us. As soon as one of them went under the water we were given the signal and would come out. We felt perfectly safe so long as they were on the surface, for in that condition they were afraid to approach us. I recall an amusing instance on the Apalachicola River, Fla. I had a mongrel dog, who



Ready and anxious for another shot.

grew mangy to such an extent that I wanted to get rid of him. Humane methods of putting dogs to sleep—such as feeding them with a pill of cyanide of potassium, were not known. My boyish fancy induced me to try the sport of throwing the dog into the water in the midst of alligators; so tying a leash to his collar I drew him down to the edge of the river on an old dock reaching out one hundred feet or so from the shore.

This dog hated the water, and more than that he hated the presence of alligators, so that when I drew him near the edge of the dock he set up a big howl which drew a dozen alligators to the scene. They came so near that several of them were almost under the dock, and at the psychological moment, while I was pulling the dog with my back to the water, the leash broke, with the result that I fell backward into the water in the midst of the alligators, while the dog ran gaily home. Both lives were saved.

During one of my visits to Panama I was present at an afternoon reception given by the President of the Panama Republic, Señor Arosemena. As I stood by the side of His Excellency thinking to tell him about my thrilling alligator hunt, the sound of martial music fell on our ears. "You must excuse me, gentlemen," said the President, "I must go out on the balcony of the palace and review our troops as I have promised." Having received his gracious permission to go too, I saw 75 little soldiers march in review.

"Is this your entire army," I asked.

"Yes, except for about 60 men who are at Colon, but" said he, "Why should Panama have an army?

This is really our police force, for you (putting his hand on my shoulder) protect us. If we should be attacked from without or if we should have trouble at home, the United States will, according to agreement, send its troops and its warships to protect and defend us.

And you may imagine what a relief that is to me, not only because it insures peace in my country, but the money which we should be compelled to raise for armaments is now spent for schools and internal improvements." Here was an object lesson, it seemed to me, greater than the building of the canal, more interesting (if such a thing can be) than an alligator hunt on the Chorrera River.

One of the big victims—Ten feet six inches long Captain Shanton, a Roosevelt rough rider, has his hand on his hat. Congressman R. Wayne Parker of New Jersey wears a black hat. The writer is just in front of Congressman Parker.

The cheapest method of handling gravel in placer mining operations is by hydraulic mining says a report of the Bureau of Mines. In working gravel deposits by hydraulic mining, it is essential that an abundant supply of water under sufficient head can be economically developed and that there is sufficient grade for sluice boxes and for disposal of the tailing. Without dumping facilities, simple hydraulic mining is an impossibility. The cost of hydraulic mining may range from two and one-half cents a yard under favorable conditions to twelve or even twenty cents under less favorable conditions and to 35 cents or more a yard in Alaska, according to conditions of operation, and if frozen gravel is encountered.

The heroic statue of Civic Virtue by Frederick W. MacMonnies, the central figure of the new fountain in City Hall Park, is carved from a block of Georgia white marble said to be the largest block ever quarried in this country.

Bridging the Delaware Between Philadelphia and Camden

The Delaware River Suspension Bridge Will Have a Length of 750 Feet Between Supporting Towers and a Total Width of 125 Feet

By SIDNEY MORNINGTON

ON THE 6th of January of the present year, with appropriate ceremonies, the mayors of Philadelphia, Pa., and Camden, N. J., attacked with silver-plated axes the wooden pier at the foot of Vine Street, Philadelphia. This marked the initiatory stage of a work of demolition, for on the site of the pier will ultimately be reared one of the two towers which will hold aloft the great span which is to bridge the Delaware River and to link the neighboring cities. From now on, the undertaking is to be prosecuted at such a rate as will put this aerial vehicular highway in service by 1926.

For many years, ferries have been the only mediums by which vehicles, millions of commuters, and persons living near the shores of these municipalities could cross the Delaware from day to day. At best, river transportation of this sort is not an ideal solution of the problem of intercommunication; and everyone knows that fog, ice, and other circumstances hamper and delay water-borne service. Similarly, schedules are at times hard to maintain, and there are bound to be gaps inasmuch as no more vessels are run than profitable traffic warrants. At rush hours, and in fact throughout the busy portions of every working day, the line of waiting vehicles is commonly a long one and is disposed of only after seemingly interminable waiting periods. To business and industry, especially, this has been costly, and, undoubtedly, has entailed outlays that would pay over and over the sum that is now to be spent in bridging the river.

This splendid enterprise will call for an expenditure of substantially $29,000,000; and the sum will be provided by the City of Philadelphia and the States of Pennsylvania and New Jersey. It is interesting to recall that the project will represent the consummation of plans intermittently advocated for more than a century. That is to say, as far back as 1818 applications were made first to the legislature of New Jersey and later to that of Pennsylvania for authority to build a bridge from Camden to Philadelphia—a distance of 2200 feet.

The desirability of such a structure was emphasized as the cities grew and became the focal points for an exchange of traffic converging there from ever-widening zones of population, manufacture, and food production. In this connection it should be noted that vast quantities of fruits and vegetables are dispatched to Philadelphia continually during the growing season from the fertile outlying farmlands of New Jersey. But despite these naturally urgent conditions, no organized movement was made to effect the bridging of the Delaware at the point concerned for vehicular use until 1914. Then, on the 17th of April, the legislature of New Jersey approved an act for the appointment of a commission with "power to construct one or more bridges or tunnels under or over a navigable stream or river which is a boundary of the state." Three years later, the State of Pennsylvania took official cognizance of the matter, although the city councils of Philadelphia had been studying the subject since the latter part of 1914.

In 1919, when engineering reports were available which confirmed the feasibility of spanning the interstate stream, the legislatures of Pennsylvania and New Jersey passed uniform laws, creating the present Delaware River Bridge Joint Commission, fully empowered to proceed with constructional work. The fact that the undertaking is now in hand should be of decided interest to the readers of this magazine, because compressed air in various ways is going to figure important in laying the very foundation of the bridge and in producing and putting together a large share of the steel fabric.

As might be supposed, no inconsiderable measure of the labors of the technicists identified with the project has been devoted to determining the most practicable location for the span and its approaches. Several factors have influenced the engineers in their choice, such as property values; topographical and geological conditions; centers of population; and the areas contributing the greater volumes of traffic. All told, five lines were considered upon which the bridge could be reared with advantage to both municipalities; and after a careful analysis of the elements involved the route linking Franklin Square, Philadelphia, with Pearl Street, Camden, was selected. It goes without saying, that due regard has been given to the present as well as the probable future needs.

Before the plans for the bridge could be drawn it was essential that the Government's requirements should be known, inasmuch as the Delaware, at that section, is a water highway navigated by shipping of all sizes. The Chief of Engineers of the U. S. Army announced that "a bridge with no piers between pierhead lines, and with a clearance of 135 feet at mean high water for a width of 800 feet extending 400 feet on either side of the span, is permissible over the Delaware River between Philadelphia, Pa., and Camden, N. J." This meant that the crossing would have to be made by a single long span reaching from pierhead line to pierhead line on the flanking shores; and the structure has been designed in accordance with the Federal limitations.

After much deliberation, the technicists decided upon a type of suspension bridge. They were influenced in this by reason of economy and greater ease and safety of erection, not to mention shorter time of construction, than would be the case if a cantilever type of bridge were adopted. Therefore, the design was evolved around a main feature of two large suspension cables. It was further agreed that the bridge and its approaches be built to provide a single deck carrying an unobstructed roadway for six lines of vehicles, for two lines of surface cars, and for two lines of rapid-transit trains, and that two ten-foot sidewalks be available above the roadway for pedestrians. Finally, it was prescribed that the foundation caissons of the main piers be sunk to bedrock.

In connection with the latter item, it seems that the supporting ledge along the route chosen lies at a depth of 86.7 feet below mean high

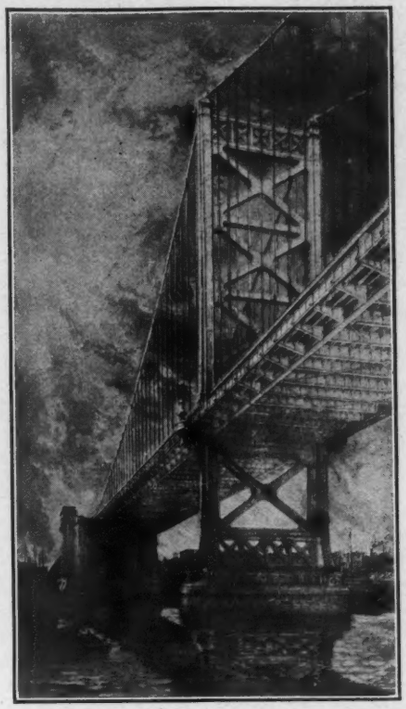
The Delaware River Bridge as it will appear when finished. At the left is the waterfront of Philadelphia, and on the right is the shoreline of Camden.

water on the Philadelphia side and 91.6 feet on the Camden side of the river. Had either of the two other strongly advocated sites been selected, a satisfactory rock foundation would have called for the sinking of caissons to a maximum depth of fully 111 feet. This would have added seriously to the stresses imposed upon the "sand-hogs" and have increased considerably the cost of this phase of the enterprise. As those familiar with work of this sort know, at depths between 110 and 115 feet, men can labor for only half an hour at a time; and even then, unless handled with much care, they are likely to develop "bends" and kindred caisson diseases. As it is, this part of the task can be put through confidently and with reasonable safeguards by means of compressed air.

Preliminary to settling upon some of the dimensions, it was essential that the engineers ascertain the traffic which the finished bridge would have to accommodate. There were no local spans which could be taken as a guide in this matter. However, the experts were able to arrive at a correct judgment by considering the service conditions on the four great East River bridges linking the Borough of Manhattan with the Borough of Brooklyn of Greater New York. These bridges, in effect, constituted a full-size working laboratory, and furnished much valuable data regarding roadways and their practicable capacities. In short, the investigators learned a number of things which might be avoided to advantage. It should be of interest to cite these, because they are evidence of how needs alter in the course of time, and how, in planning a bridge between populous communities, the architectural engineer should look a long way ahead.

To quote: "The experience with the Brooklyn Bridge has proved the inadequacy of allowing but one line of vehicular travel in each direction. On the Williamsburg Bridge, provision was made for two vehicle lines each way, in separate roadways. These have not proved satisfactory, as they are easily obstructed by a single vehicle occupying the middle instead of its proper side of the narrow road. A breakdown in such a case blocks all traffic in that direction. When the Manhattan Bridge was designed, somewhat later, a single 35-foot roadway, considered wide enough for four lines of travel, two in each direction, was placed on the centerline of the structure. This is considerably more popular with drivers than the Williamsburg roadways, and actual observations show it to be capable of handling a greater maximum number of vehicles per hour. It is found, however, that when carrying heavy traffic with slow vehicles confined to the outside lanes of travel, trouble is caused by the attempt of autoists in the two inside lanes to pass around those ahead of them. There is hardly enough flexibility in the arrangement to accommodate present-day mixed motor and team traffic when approaching capacity load conditions.

"The Queensboro roadway is 53 feet two and one-half inches between curbs. Originally it was intended to operate two surface car tracks in this roadway just inside the trusses.



A view of the main tower on the eastern or Camden side of the river. This tower will rise to a height of 380 feet above the surface of the water.

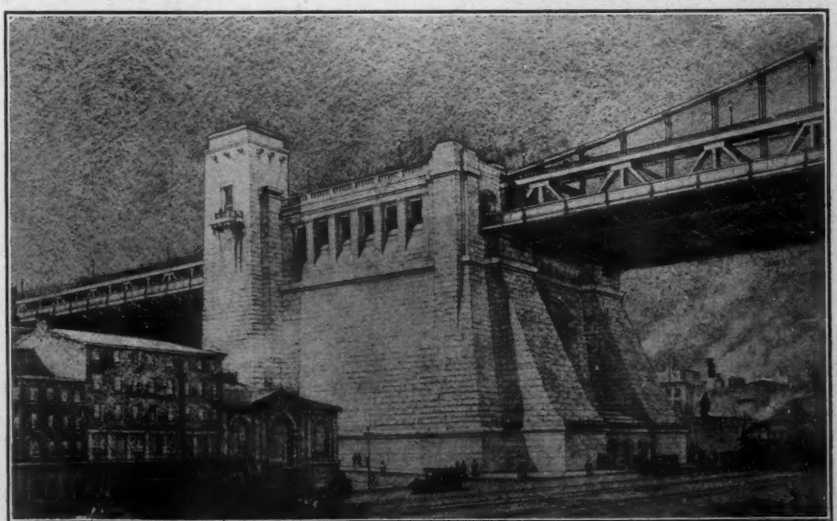
Tunnel connections to Long Island, however, have made these tracks unnecessary, and the entire width of roadway is now devoted to vehicular traffic—affording six lanes of about eight feet ten inches each. The result is a roadway, with great flexibility, that is very popular with all drivers and which can handle almost double the traffic of a four-lane roadway like that on the Manhattan bridge.

"We considered that not less than six lines of vehicular travel should be provided for on the bridge over the Delaware. In view of the width of motor trucks now operating, we increased the width allowed for each line of travel beyond that furnished on the Queensboro bridge, i. e., nine feet six inches, and fixed the width from curb to curb on the main structure at 57 feet. The present-day cross-river passenger traffic would require two lines of track for the establishment of a bridge shuttle-service. The desirability of later extending high-speed transit service over the river was considered in the provision of two additional tracks for that service, making four in all."

Similarly, the question of gradients for the approaches was studied. The gradients of the vehicular roadways will not exceed three and one-half percent., while the maximum gradient generally for both the rapid-transit and the surface-car tracks will be about five per cent. except, in the case of the rapid-transit lines, where, for a short distance at one point, the gradient will be 5.22 per cent. in connecting with subway.

The Delaware Bridge is to span a gap of 1690 feet between pierhead lines; and, as a matter of fact, the suspended structure will have a length of 1750 feet from center to center of the supporting towers. We can best realize what this means in the way of an advance in the art if we compare this bridge with some of the notable older ones. During the last half century, since the Brooklyn Bridge was designed with a span of 1596 feet, only one suspension bridge, the Williamsburg edifice, has attained a greater length—i. e., 1600 feet. The Delaware Bridge, therefore, will mark an important development, inasmuch as its span will surpass by 150 feet the longest suspension bridge that is now in existence.

The floor system will have a total width of 125½ feet, and thus be two and one-half feet wider than the Manhattan Bridge, which was opened for service on the last day of 1909. This floor system will be sustained by two steel cables. Consideration was at first given to the employment of four main cables, as are used in the East River bridges, but this idea was abandoned after investigation. With the traffic arrangements as settled upon for the Delaware Bridge, the adoption of four cables would have involved a width between outside tower legs of 118 feet and



Perspective view of the anchorage which will be located at Race Street and Delaware Avenue, Philadelphia.

have called for pier caissons 170 feet in length. The two-cable design, on the other hand, permits the columns for each tower to be placed only 89 feet apart and will make it possible to save 25 per cent. in the cost of the main piers alone. In fact, the plan chosen will effect considerable economies in a number of directions and will possess, besides, the advantage of a much more definite distribution of the load to the cables.

The main supporting cables of the Brooklyn Bridge have a diameter of fifteen and three-fourth inches, and those of the Manhattan Bridge measure twenty and one-half inches across. The cables for the Delaware River Bridge will be 30 inches in diameter; but while of unprecedented size their manufacture and erection, so we are told, will entail no new or untried procedure. Everyone of the 16,500 high-carbon steel wires composing each cable will have a diameter of 0.192 inch. These wires will be laid in place individually and parallel so as to make up 61 strands, and these strands will be subsequently bound together and wrapped with serving wire for the purpose of forming a complete cable. At intervals of 20½ feet, each main cable will be gripped by a cast-steel saddle. Over this saddle, and hanging therefrom, will be four galvanized ropes, each two and five-eighths inches in diameter, which will be attached to the pendant floor system. The latter will consist of fabricated steel units; and in their production and final installation pneumatic tools of various sorts will figure extensively.

As has been well said, next to the cables, the most important members of a suspension bridge are the towers. In earlier suspension bridges, with relatively short spans and carrying comparatively light loads, the builders generally relied upon masonry towers. The Brooklyn Bridge, even with its long span, has stone towers; but in all succeeding suspension bridges of kindred magnitude the towers have been fashioned of steel. The reason for the departure from masonry has been purely a matter of practical engineering.

Another view of the west or Philadelphia anchorage, showing granite buttresses at the cable ends.

Under different conditions of loading, the resting points of the cables on the tops of the towers are subjected to considerable horizontal displacements. For some time it was the common practice to place the cable saddles on roller beds, which were counted upon to accommodate these movements. Experience, however, has disclosed that on some large bridges the rollers and saddles do not, in fact, move until frictional resistance of pronounced magnitude has developed. This means that the towers, themselves, must bend to neutralize the horizontal pull of the cables. Masonry towers, of the dimensions required for a long-span bridge, would not be able in this way to react to the degree demanded.

The designers of the Delaware Bridge have, therefore, wisely decided to put no dependence upon the uncertain response of rollers, and have chosen to fasten the cables securely to the tops of the towers and to build the latter of steel. Thus, while adopting towers having slender and graceful lines, they have made certain of sufficient strength to withstand any bending stresses that may be set up in service. These towers will rise to a height of 380 feet above the river's surface. The tower legs are to have a width, parallel to the cables, of twelve feet at the top and widening gradually downward to 40 feet at the base. The legs are to be substantially braced in order to form a unit.

In shore, on each side of the river, the suspension cables will be moored to a massive, monolithic anchorage composed of 90,700 cubic yards of masonry. These anchorages will rest on gravel strata and upon inclined caissons extending down to rock or other satisfactory material. To avoid any possible doubt as to the resistance of the anchorages to sliding, it is the intention to sink twenty small caissons to hard foundation under each structure, and these caissons will have the same inclination as that of the resultant of the forces to be met. At the points where the cables enter the anchorage they will find support and be given a change of direction in passing over saddles set upon steel pedestals. The pedestals transfer the load downward into the masonry. After a cable has been laid over an anchorage saddle, its strands will be connected to a chain of 122 eyebars, which, in turn, are to be fastened to steel girders embedded in the base of the monolith.

For those fond of details, it may be said that the assumed live loading of the bridge under working conditions has been placed at 6,000 pounds per lineal foot for normal unit stresses. It is recognized that the average everyday loading will be considerably less. The roadway floor has been designed to bear anywhere a moving load of 30 tons. Owing to the massiveness of the main structure it has not been deemed necessary to make allowances for impact; but this factor was given due weight in planning all parts of the floor system and the associate members that might be called upon to absorb direct stresses therefrom.

In their calculations, the engineers estimated that "wind loading" would cause a pressure of 50 pounds per square foot of exposed area; and temperature stresses were computed for a variation of 55 degrees Fahrenheit above and below a normal temperature. One does not have to be a technicist to realize that temperature changes at different seasons of the year would induce pronounced stresses in the great main cables, especially when they were acted upon by the expanding heat of summer or the contracting cold of a frigid winter.

In order to assure an easy and rapid flow of traffic across the bridge, even when operating to capacity, the architects have been mindful of the desirability of commodious approaches. The Board of Engineers has wisely said: "It is obvious that a bridge will carry no more traffic than can get on its approaches. Great width of roadway on the bridge will be wasted expense unless adequate provision is made at the terminals for receiving and distributing the traffic from and to the network of the city streets. Not only must there be roadways

A bird's eye view of the plaza and approach to the bridge on the Camden side of the river.

The bridge plaza at the Philadelphia end of he bridge. This plaza is located just east of Franklin Square; and the bridge approach is seen at the right.

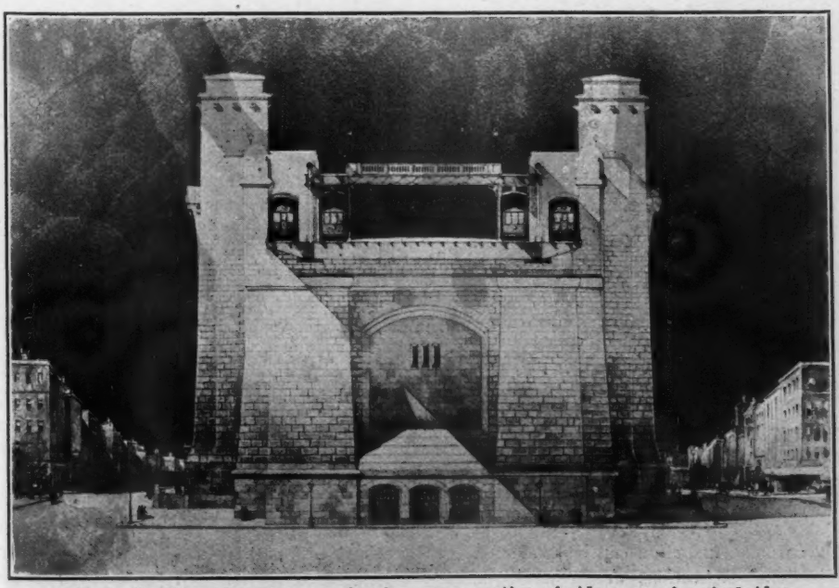
leading from the bridge end in several directions but these must radiate from an ample paved space in which distribution can take place." To this end, the bridge plan contemplates spacious plaza developments at each end of the span.

Considered from every angle, the Delaware River Bridge, which is to bind Philadelphia and Camden, will prove an invaluable aid in promoting intercourse between the near-by cities and the two States immediately concerned. It will be a monument to civic enterprise, evidence of a notable advance in the art, and a spur to other sections of the country to adopt similar measures. Better means of intercommunication and the distribution of commodities of all sorts are sorely needed particularly in those parts of the country where production is carried on intensively. The automotive vehicle is rapidly revolutionizing some phases of transportation; and to make the most of this type of conveyance it is indispensable that the routes of traffic be open from end to end—not interrupted by water courses that can be crossed only by ferries.

"AIR LIFT" CLEARS SAND FROM DEEP WELLS

Dennison Fairchild in *Engineering News-Record*, Jan. 26, cites two interesting cases in which air lifts have been successful in removing sand plugs in deep wells. "One well, with an eight inch casing 145 feet deep (from which about 100,000 gal. of water was pumped daily), became clogged with sand to such an extent that it practically stopped the supply. A test developed fourteen feet of sand and small gravel. A three-fourths inch pipe to the sand was inserted and air forced to the bottom, the rising bubbles keeping the water disturbed and the sand in suspension, and it was thrown out very quickly and at little expense. In another case, the well was 236 feet deep with an eight inch casing, and the sand was beginning to shut off the supply and get into the pump. There was available only 150 ft. of one-half-inch pipe which was connected up with a compressor. The rising air created enough suction to lift the sand and the water was clear and running free of sand at the end of 25 minutes.

While in the cases here cited, the compressed air injected below the sand plug removed the obstruction very successfully, it should be noted that arrangement was not what is properly known as the air lift.



End elevation of anchorage showing cross section of side span of main bridge.

THE DETROIT-WINDSOR BRIDGE

Plans for the new international suspension bridge to connect Detroit and Windsor, just announced, show that it will have the longest single span in the world, measuring 1802 ft., or 24 ins. longer than the great cantilever at Quebec, according to a recent issue of the *Engineering World*. Of double-deck construction, the new link between Canada and the United States will accommodate street car, automobile and pedestrian traffic on the upper deck and passenger and freight-train service on the lower deck.

Barring unforeseen delays, actual construction work will commence next spring and within four years the upper deck should be ready for service. Without interfering with traffic on the highway deck, it is planned then to begin construction of the lower deck, which should be finished in two years more.

The bridge and its approaches will have a total weight of 107,000 tons, with eight cables carrying the huge span. Six of these cables will be 21 ins. in diameter and two will be eighteen inches thick; together they will support a pull of 146,000,000 lbs.

Suspended from two towers, each rising 380 ft. above the water, the span will have a width of 97 ft. for the highway deck, with two trolley tracks, two sidewalks and two roadways, while the lower deck will have four railway tracks and a twenty-foot space for public utilities equipment. Electric locomotives would be used for traffic across the lower deck.

Completion of the bridge will mean the end of the train ferries, which for years have carried freight and passenger trains across the Detroit river, even after the opening of the Michigan Central tunnel.

The bridge, which will be built by the Canadian Transit Co. and the American Transit Co., with the approval of the Canadian and United States governments, will span the river almost from the center to the shore line of the two cities. Construction is expected to begin from the American side.

The promoting companies have been authorized to issue $30,000,000 in securities for the project. It is estimated that completion of the highway or upper deck will cost approximately $15,000,000.

Purchase of shore space for the approaches is under way.

Plans for the bridge were drawn chiefly by Charles E. Fowler of New York. Associated with him in the erection of the structure will be George H. Pegram, chief engineer of the Interborough Rapid Transit Co., New York; Prof. William H. Burr of New York; Col. C. M. Monserrat, Montreal; Prof. C. R. Young of the University of Toronto, and Prof. H. E. Riggs of the University of Michigan.

Over a half billion cubic feet of storage space is under refrigeration in the United States for the preservation of foodstuffs.

Underpinning With and Without Compressed Air

Difficult and Dangerous Work Done Safely and Efficiently by the Breuchaud Pneumatic Process and with Other Compressed Air Equipment

By FRANK W. SKINNER
Consulting Engineer

VERY LITTLE CONSTRUCTIONAL engineering work is more difficult and troublesome than underpinning tall and heavy structures, and none is considered more undesirable by engineers or contractors who are likely to lose heavily both financially and in reputation through difficulties and developments which they may not be able either to foresee or overcome.

Generally such work is necessitated by emergency and must often be executed under adverse conditions, with insufficient information for the preparation of preliminary plans.

Ordinarily underpinning has heretofore been done by elaborate methods that temporarily increase the instability of dangerous structures which the work is planned to eventually safeguard. The danger is eliminated and the operations simplified when the work is done by the Breuchaud cylinder and compressed air process which is well adapted to the most difficult conditions, even those that make the application of the old methods very costly and dangerous, or impossible.

Underpinning in its broad sense is replacing, repairing or sometimes only safeguarding the wall or pier footings of a building, bridge or other structure.

It is required for various reasons, including the inadequacy or unreliability of existing foundations because of defects of design, material or workmanship; deterioration; increased load; change in support under the foundations; present or threatened softening, scouring, or bleeding of the material liable to cause undermining and settlement; vibrations due to impact or other disturbances, adjacent excavations; the increase or elimination of ground water, or to various other causes.

Underpinning operations are likely to be more difficult and dangerous the taller and heavier the structure, the deeper the foundations, the more delicate the contents of the building, the closer and more important the adjacent structures, and the softer and more treacherous the soil.

Foundations for structures on land or in the water are of three general types, namely: carried down to rock; supported by the bearing power of the soil either near the surface or in pits; and those supported wholly or largely by the frictional resistance of the soil, as is the case with many pile foundations and some pier or caisson foundations that are sunk through soft materials and do not reach a hard stratum.

Foundations on rock seldom or never need underpinning if properly designed and constructed. Foundations with their bearings on the natural soil are most likely to need underpinning, especially if near the surface, if the soil is of a treacherous nature, or if it is disturbed by subsequent operations nearby at a level below the bottom of the footings. Frictional foundations are generally carried down so deep that they are beyond the influence of ordinary operations in the vicinity and are most likely to need underpinning on account of changes in their loading or through the deterioration of the foundations themselves, as may occur when wooden piles decay.

WHEN THE 4-track Rapid Transit subway was built under the massive City Hall, Philadelphia, compressed air played a very important part in the most extensive and costly piece of underpinning ever undertaken.

The ponderous masonry of this building was carried on hundreds of steel piles driven in narrow pits and tunnels by air hammers; while other pneumatic equipment served in various functions.

Old complicated methods have been replaced by the more efficient and simpler Breuchaud process on a great many important underpinning operations.

Old foundations of tall office buildings have been supported by slender steel cylinders driven by compressed air through water and perhaps quicksand to the rock far below without, in many cases, even entering the buildings to accomplish the work.

Ordinary Underpinning

The first step in underpinning is to make an accurate survey of the structure and record all existing injuries and imperfections so as to locate the weak points and incipient failures and quickly detect new or progressive injuries during the underpinning operations; the second is to remove obstructions and secure access to and clearance for the work; the third to strengthen and safeguard the building against any injury or loss of stability possible from the subsequent underpinning operations.

It is sometimes necessary to repair not only the foundation, but the building itself and to brace the walls thoroughly and shore them before even an examination can be made. After this is done excavations are generally made around the old foundations exposing them for inspection, repairs or replacement. If they can be partly or wholly replaced or extended to rock or satisfactory hard stratum at a moderate depth this is ordinarily done in successive sections, if not, they may be carried down to better bearings at what is considered a safe depth, or they may be strengthened, extended, or protected according to requirements.

Ordinary Shoring and Underpinning

The most common way is to transfer the weight of the superstructure to the temporary new surface foundation, remove the old foundation, excavate to satisfactory bearing, construct new foundations there, transfer the weight of the building back to them and remove the temporary supports. This involves "shoring" or the temporary support of the structure, and underpinning proper, or the actual revision of the foundations.

Often the wall is braced with inclined exterior adjustable struts and holes are cut a few feet apart in the walls just above the foundations, and in them are inserted transverse beams or girders, called needles, with their ends carried on timbers that distribute their loads over the surface of the ground at a distance from the wall.

Jackscrews or their equivalents are operated under the ends of the needles to lift the wall slightly, usually developing a crack between it and the foundation, and permitting the latter to be removed and a trench excavated under the wall between the needle supports.

In the trench the new foundation, usually of concrete, is built up to the needles and between them, close to the old wall, which is thoroughly wedged to bear upon it, after which the needles are slightly lowered, transferring the weight of the wall to the wedged support and imposing concentrated loads on the new footing which tend to develop any potential settlement there and produce permanent equilibrium. The needles are then successively withdrawn and replaced by completing the intermediate portions of the foundation and wedging them tightly against the bottom of the wall, thus completing its support.

During these operations it is necessary to constantly take measurements and to adjust the jackscrews to compensate any settlement. Carelessness is likely to result in serious cracks or destruction of the walls.

Simple Needlebeam Method

Underpinning a tall, heavy building under the most favorable conditions by the old fashioned method is illustrated by the Decker Building, New York, with a thirteen story brick wall, 100 feet long, that weighed with its load, about 30 tons per linear feet, besides containing iron columns carrying loads of 500 to 650 tons each.

The wall was temporarily supported on double tiers of 15-inch I-beams 28 feet long with each end carried on four lines of 12x12-inch timbers parallel to the wall. These in turn were carried on 20-ton and 5-ton jackscrews placed as close together as could be conveniently operated on a plank platform on top of a pair of lower parallel sills on timber cribs built on concrete piers carried down to solid rock in sheeted pits.

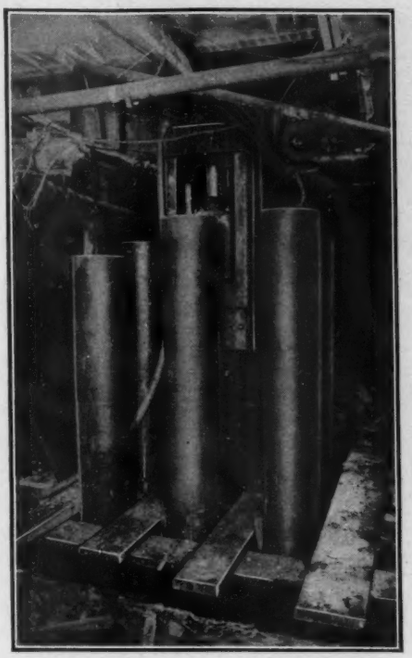
After the needle beams under a section 30 or 40 feet long were jacked up to lift it ⅛ inch, the footings were removed and a trench was excavated from five to fifteen feet deep to rock between the cribs and new foundations were built in it. As soon as the new masonry was hard enough, the weight of the wall was transferred to it from the needles, compressing the new brickwork a fraction of an inch, and the needles were removed, their places filled by extensions of the new foundations, and the operations repeated on successive sections of the wall until the whole was finished. During the operation temporary loads of 100,000 pounds per square foot were carried on the new foundations and accurate levels were taken daily on fourteen bench marks. The wall was thoroughly braced by inclined struts and by heavy horizontal timbers reaching across the cellar excavation.

Breuchaud Method

The Breuchaud method of underpinning, which has been very extensively used for some of the tall buildings in New York, eliminates the delay, danger and expense of shoring and of disturbing previous old foundations. It consists essentially of jacking down hollow cylinders under the old foundations until they reach satisfactory bearing and are filled with concrete and adjusted to permanently support the weight of the wall. This process employs the weight of the structure itself to afford reaction for the jacks, does not involve the removal of any appreciable amount of the old foundation bearing or the disturbance of the footings, and therefore does not impair the original support of the building.

It provides increased rather than diminished support during the process of underpinning and has the very great advantage that it occupies the minimum possible amount of space for the underpinning work and may be done wholly from either face of the wall. It does not necessarily require the use of any needle beams, inclined struts or any other shoring, and may be done on the exterior face of the wall without entering the building or may be done from the interior of the building without at any time occupying the exterior space.

In many cases in New York City old footings were carried to ground water line, and in order to avoid difficult excavation and pumping in the bottom of the pit, the jacks are often installed above the bottom of the old footing. For this purpose the face of the footing, and perhaps the lower part of the wall, is recessed to form a chamber from two to four feet wide and deep, and from five to eight feet in height, large enough to receive the first section of the cylinder, jacks and reaction beams seated above it. At the top of this vertical recess there is cut a horizontal recess in which are seated one or more I-beams to take bearing against the wall and distribute the pressure over a sufficient area to provide for the reaction of the jacks in forcing down the cylinders.



A cluster of long, hollow steel piles driven in a pit in the cellar of a building without disturbing any of the dwellers. The piles are driven by a heavy compressed air hammer suspended from the basement floor and working with very small clearance.

The cylinders, from 30 to 80 inches in diameter, are usually of steel pipe with sleeve joints for the smaller sizes and of cast iron with interior bolted flanges for the larger sizes, and are used in sections from three to twelve feet in length. They are sunk with open ends permitting the material encountered to rise inside and be frequently cleaned out at intervals between the jacking or while the jacks are being shifted. For the smaller sizes the material is generally excavated with scoops of other special tools or blown out by compressed air, care being taken if the bottom of the pipe is in a quicksand stratum, to avoid a run-in of quicksand that might cause injurious settlement to adjacent structures or to the foundations of the building itself.

If the pipe has a diameter of 30 inches or more it is possible for a man to enter and excavate the material by hand, depositing it in a canvas bag, which is hoisted through the pipe and emptied. As the sections of the pipe are driven down additional sections are connected on top and flange bolted to them for the larger sizes.

Pneumatic Pressure Applied

When the lower section reaches ground water level, a special upper section is installed, having top and bottom horizontal diaphragms with gasketed air tight doors, both opening downward. This section is fitted with valves and gages and serves as an air lock through which a man enters the cylinder after air pressure is applied to expel the water from the lower part of the cylinder. In this way the cylinder can be sunk a maximum of 100 feet through water and quicksand to bearing on bottom that can be carefully examined and leveled and in some cases covered with thick plates to increase the bearing and of the lower end of the cylinder.

This method was invented by Jules Breuchaud, president of the Underpinning and Foundation Co., who first applied it to the underpinning of the 144-foot high brick wall of the Queen Building, New York, the original footing of which rested on fine sand above ground water level and about 36 feet above the rock. The footing eight feet wide was subjected to a load of about 12,000 pounds per square foot and was underpinned by cast iron cylinders 33 inches in diameter that were loaded to about 350 tons each.

The same process was used for underpinning many other tall and heavy buildings in the

Workmen with pneumatic rock drills and Jackhamers trimming old rubble foundations. Subway roof temporarily supported on vertical timber shows end wedging.

financial district of New York, previous to making deep excavations alongside or sinking caissons in quicksand for the foundations of new buildings that would inevitably cause some subterranean displacement of soil and "bleeding" of the fine wet sand, likely to produce settlement in the old buildings and subject them to heavy stresses, distortions and serious injury.

In doing this work compressed air was freely used, not only for expelling the water in the cylinders, but for operating drills with which the masonry was honeycombed, and broaches with which the brickwork was cut out. Later it was found generally cheaper, quicker and more advantageous to drive smaller and more numerous piles with air operated hammers and to clean out the material with compressed air blow-outs that obviated excavating and hoisting equipment.

In any case a very small working force suffices, and is divided into units of two or three men for operating the compressed air drills and broaches for honeycombing and removing the masonry where recesses have to be cut in the old walls. Another group places the reaction beams, handles the cylinders and acts as general utility men, while the third group consists of one compressed air man and two jack men to drive the cylinder under the wall. Besides this there is probably one man at the derrick hoist, perhaps one or two extra men and a superintendent. Usually, however, two or more cylinders are driven simultaneously at points as widely separated as convenient, and an additional group of excavating and jacking men, drillers and broachers are required for each simultaneous cylinder.

The cylinders are always driven at least to bearing on the hardpan and frequently are carried several feet through the hardpan or to the solid rock immediately underlying it or perhaps separated from it by a pocket of quicksand. In some cases the cylinders might reasonably be stopped soon after penetrating the hardpan and the remainder of the excavation made beyond their lower ends, but it is generally customary to carry them to the extreme bottom of the pit and thus secure the benefit of the

Excavating for the subway under the City Hall, Philadelphia. New foundations have been successively built up on either side to help carry the building load.

compressive strength of the cylinder metal throughout the full length of the column.

The cylinders are generally driven by one or two 60-ton or 100-ton hydraulic jacks, sometimes operated by hand with two men each, and sometimes driven by a pump actuated by compressed air necessarily provided for the interior of the cylinders.

In some cases walls so dilapidated that they would not hold together unless continuously supported, have been successfully underpinned by this method even when it was necessary, as in case of the work done for buildings adjacent to the Mutual Life Insurance Building, New York, to strengthen and even encase the lower part of the wall by pairs of deep plate girders bolted to and through it and providing satisfactory bearings for the hydraulic jacks.

After the cylinders are driven to satisfactory bearing on the rock surface they are filled with concrete and heavy iron or steel cap plates are seated on them bedded in grout. Connections are then established between the cap plate and the reaction beams by means of short vertical steel columns, securely wedged to bearings adjusted to take the required proportion of the weight of the wall. The recesses in the brick work around the beams and struts are afterwards filled solid with new masonry and grouted, completing the work.

Double tier of plate girders supported on new footings to carry the northwest tower (225 feet high) of the City Hall, Philadelphia. On construction such as this, pneumatic drills, reamers and riveting hammers were a necessary part of the equipment.

Philadelphia City Hall

Compressed air played a very important part in the most extensive, difficult and costly piece of underpinning ever undertaken: namely that of the City Hall, Philadelphia, which was required by building under it the 701x106 foot station of the 4-track rapid transit subway, 25 feet high overall, with the roof about fifteen feet below the street level; an undertaking that necessitated very critical operations in lifting, transferring and maintaining about one-fourth of the great weight of the enormous building while a large part of the old foundation was wholly replaced and the subway station was constructed.

The City Hall, at the intersection of two of the widest and most important thoroughfares in the metropolis, is a beautiful and ornate example of French Renaissance architecture, covering four acres of ground and rising to a general height of eight stories or about 125 feet. It is entirely of brick and stone construction, built about 1880 at a cost of $24,000,000.

When examinations were made to plan the subway construction it was discovered that the masonry walls were in good conditions down to the cellar floor about eleven feet below street level, beyond which the foundations consisted generally of loose rubble stone, with little mortar and no cement, piled up with large interstices between them in trenches excavated in the dry gravel 40 or 50 feet above the rock in most places.

Most of these footings, carrying an estimated weight of about three tons per square foot, were in such a precarious condition that they could not be even slightly disturbed without serious danger, and it became necessary to support the massive structure above them while they were entirely replaced by new foundations, the subway constructed and 150,000 tons of the weight of the City Hall transferred to permanent support on the subway roof, all without any injury to the building or accident to workmen, tenants or citizens.

After operations were commenced the condition of the old foundations was found to be so bad that it was impossible to carry out the original plan of supporting the building on an elaborate system of caisson foundations and massive steel girders spanning the subway. The final plan adopted was that of reinforcing and rebuilding the old foundations, constructing a system of new girders and transferring a large portion of the weight of the superstructure directly to the subway structure itself, all of it being eventually transmitted to solid rock by steel and concrete foundation piles, driven by compressed air.

The subway structure has a rectangular cross section with five longitudinal concrete walls four and five feet thick, and reinforced concrete floor and roof slabs. The walls were built first in alternate sections four to eight feet long and supported on about 1800 hollow steel piles driven by compressed air hammers to solid rock and filled with concrete.

As the work was carried on in about 60 separate cellar rooms enclosed by massive ma-

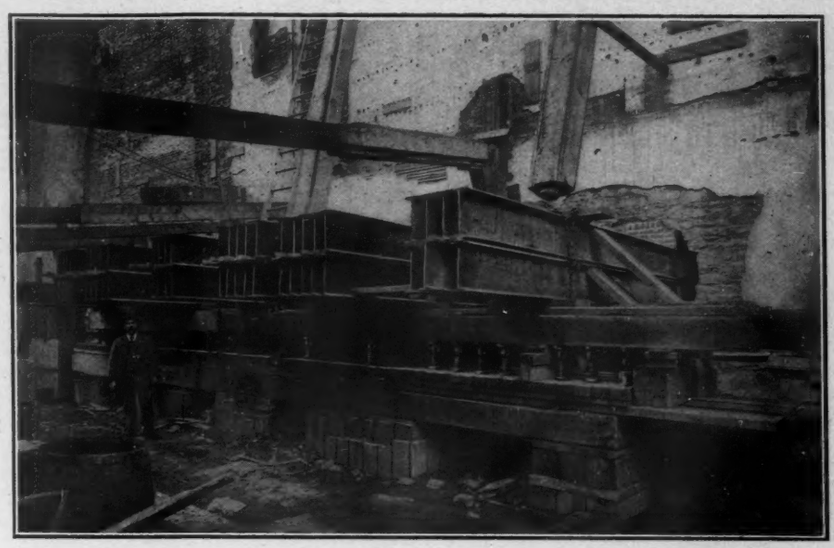
sonry walls, great difficulty was experienced in handling the long and steady steel girders in the narrow clearances, and the operations were carefully planned in advance by the aid of a wooden model of the building in which scale models of the steel girders weighing up to 40 tons, were shifted around to determine in advance how the work should be handled.

The first construction work done was the sinking to bed rock of heavily timbered construction and drainage shafts and the installation of twenty piston pumps operated by compressed air for more than three years to lower and keep down the ground water level. The shaft hoists and portable winches were operated by electricity and the six pile driver hammers, two sheet pile hammers, eighteen jackhamer drills, and the riveting hammers were all operated with compressed air provided by three electrically driven Ingersoll-Rand compressors with a combined capacity of 1,300 cubic feet of free air per minute. A machine shop and blacksmith shop were established, two concrete machines were installed to mix the 50,000 yards of concrete required, and a force of twenty carpenters was maintained building forms for the concrete girders and other work.

Shoring was commenced by passing I-beam needles through holes cut in the sound masonry above the cellar floor and through the arch door openings, and wedging them to bearing on vertical shores set on I-beam bases or concrete footings in pits sheeted down below the old footings on each side of the wall. This involved the excavation of 18,000 yards of earth and placing 6,000 yards of concrete, and permitted the removal of 2,700 linear feet of heavy walls with dry rubble footings three to twelve feet thick and 47 feet deep below the cellar floor. After the walls were shored and the footings were exposed they were found to be so loose and unstable that in some cases it was necessary to sheet and brace them like loose earth.

The construction of the five subway walls was carried on in as many as 28 different places simultaneously, in each of which there was excavated a 5x6-pit concentric with the walls and sheeted down to a depth of about 27 feet with horizontal 2x8-inch boards, having the outer edges beveled and slots two inches wide left between them to provide for inspection, tamping and packing of the earth to prevent possibility of bleeding and consequent settlement.

In each of the pits from five to fifteen-inch sectional hollow steel piles were driven, sometimes by 100-ton hydraulic jacks, but generally by steam hammers, operated by air. After driving them fifteen to twenty feet to refusal on bed rock, the water, sand, and gravel were forced out by heavy air pressure. They were then concreted and capped with cast iron plates on which the sections of the concrete walls were built and eventually united by vertical construction joints, making a very strong and massive continuous wall. The piles were proportioned for a working load of 90 tons each, and many of them were subjected to test loads of 110 tons. The piles were spliced when necessary with inside cast steel sleeves, and were cut off to exact length by oxy-acetylene flame. The length of the main subway walls aggregated more than 3,000 feet and the equal amounts of concrete and excavation required for their construction were each equivalent to a 5x8-foot prism 2½ miles long.



Underpinning a thirteen story brick wall. The latter was temporarily supported on double tiers of 15-in. I-beams with each end carried on four lines of 12x12 in. timbers parallel to the wall. The timber cribs rest on concrete piers carried down to solid rock.

One of the towers, 175 feet high, had a footing of loose, dry rubble stone that was at first enclosed by a heavy continuous concrete buttress, built in alternate sections in narrow sheeted pits and well bonded into the spaces in the old masonry, that provided an extended base and considerably enlarged the bearing surface on the soil. A recess was left between the outer face of the old footing and the buttress large enough to receive a deep plate girder that was set in position and concreted to the buttress. After the concrete was hardened a portion of the old rubble was cut away adjacent to the girder and a second girder was inserted and partly concreted and so on, until a complete system of underpinning girders had been built in and carried the tower, without at any time reducing the supporting area below what it was originally.

The work was executed at a total cost of about $3,000,000 and with a settlement that was uniform and did not settle one-quarter inch. A force from 250 to 500 men was employed for about three years by the Keystone State Contracting Co., Philadelphia, S. M. Swaab, chief engineer.

TREATING CO POISONING

Carbon monoxide poisoning is one of the most widely distributed and most frequent causes of industrial accidents, says the United States Bureau of Mines. Carbon monoxide gas is a product of incomplete combustion, and since it is without color, odor, or taste, its presence is frequently unsuspected in many places where it exists. It is an ever present danger about blast and coke furnaces, smelters and foundries. In underground mines carbon monoxide may appear as the result of shot firing, mine explosions, or mine fires, and in tunnels where automobiles, coal or oil-burning locomotives are operated.

In spite of the common occurrence of carbon monoxide poisoning there appears to be no uniformly recognized treatment for a person overcome by carbon monoxide. In the rescue work of the United States Bureau of Mines, however, a method has been developed which has been supported by laboratory investigation, and has proved successful in practical experience, over a period of years.

The first and most important thing in caring for a case of acute carbon monoxide poisoning is to get the poison out of the blood. Every moment that it shuts the oxygen out of the hemoglobin adds to the chances for failure of respiration and failure of the heart. Every minute that the tissues are supplied with only a part of the oxygen they need increases the danger of their degeneration and permanent damage. Both to save life itself and to prevent ill health in the future, it is of vital importance to eliminate carbon monoxide from the blood as rapidly as possible.

The first step is to get the victim away from the atmosphere of carbon monoxide which he is breathing; the next is to supply him with oxygen. This may be done by getting the patient into fresh air, but only one-fifth of air is oxygen. If a tank of pure oxygen is available, it is far better to use it, as the action is much faster and the after-effects, especially the headache, are much less severe and not so prolonged.

While the administration of oxygen is by far the most important factor in the treatment and cannot be over-emphasized, other things should be done to help the patient. He should be kept *quiet* and *lying flat*, to help his weakened heart. When he revives, he should *not* be *allowed* to *walk* about or in any way *exert* himself, for there is danger of heart failure.

Complete details of methods employed in the treatment of carbon monoxide poisoning, including a description of the Schaefer method of artificial respiration, are given in a report which may be obtained by applying to the Bureau of Mines, Washington, D. C.

Novel High Pressure Gas Station*

Gas Holder Tank Water Serves to Cool the Compressor Cylinder and an After-Cooler Brings the Gas Down to the Required Temperature

By R. C. CONANT

THE PHILADELPHIA Suburban Gas & Electric Company supplies gas and electricity in the suburban districts around the City of Philadelphia. On account of the size of the territory and the number of small communities supplied, high pressure gas distribution lends itself to the service required.

The Jenkintown Division of the Philadelphia Suburban Gas & Electric Company includes the territory north of the City of Philadelphia, in Montgomery County. In addition to supplying a number of boroughs with gas where the consumers are connected either direct to the high pressure mains through service regulators or are on low pressure mains fed through district regulators, there are numerous intermediate consumers on the high pressure mains in this rapidly growing suburban territory.

Gas is generated in Wyncote, located near the southern border of the territory, and is pumped with positive blowers to Oreland, where storage holders are located.

Oreland is the site that has been chosen for a future manufacturing and distribution station. From this point the Philadelphia Suburban Gas & Electric Company is in position to send out all the gas required on its high pressure system. This amounts to nearly 75 per cent. of the total gas distributed.

Late in 1920 it was found that additional capacity would be required to handle the high pressure load and not having adequate boiler capacity or space in which to install another compressor at Wyncote, it was decided to install the additional compressing capacity at Oreland.

A cross-compound Imperial-Type-XPV-3 Ingersoll-Rand compressor was purchased. The cylinders are 18x29x26x16 in. with 20-in. stroke and operate at 160 revolutions per minute. It has a delivered-air capacity, at 80 lbs. pressure, of 103,200 cu. ft. per hour, and delivers gas at 70 lbs., using 100 lbs. steam pressure.

Inasmuch as there is an apparent saving of about 25 per cent. in the steam consumption of this unit by operating condensing, a low level multi-jet condenser was installed with the compressor, handling about 5,600 lbs. of steam within 70 deg. cooling water and maintaining 26 in. vacuum.

The novel feature of this installation is that the circulating water for the condenser is taken from the bottom of the tank of the 500,000 cu. ft. gas holder and pumped back to the top of the same tank from the hot well by means of a motor operated centrifugal class DV Cameron pump.

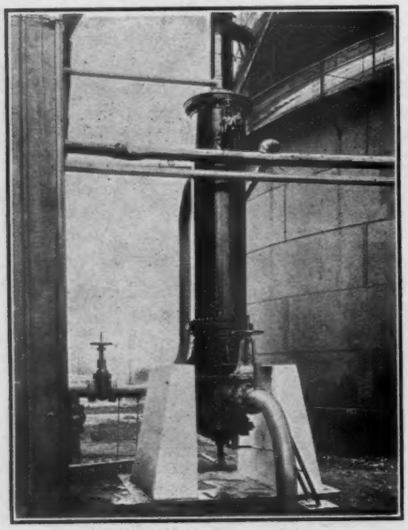
With the exception of the hot months in the summer the water from the holder tank is sufficiently cool to give the desired vacuum. During the winter the hot water returned to the tank makes it unnecessary to use any steam to heat or circulate the water in the tank, in order to prevent freezing.

The gas after compression is cooled by means of an Ingersoll-Rand No. 7 VK after-cooler.

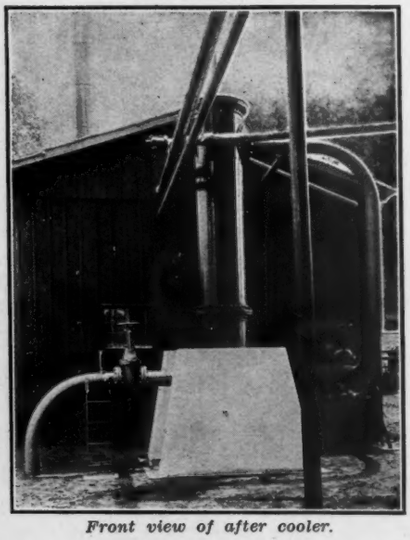
All gas and water connections were made with flanged or welded joints.

The accompanying illustrations show the general arrangement of the compressor, condenser, after-cooler and circulating pipe to and from the holder.

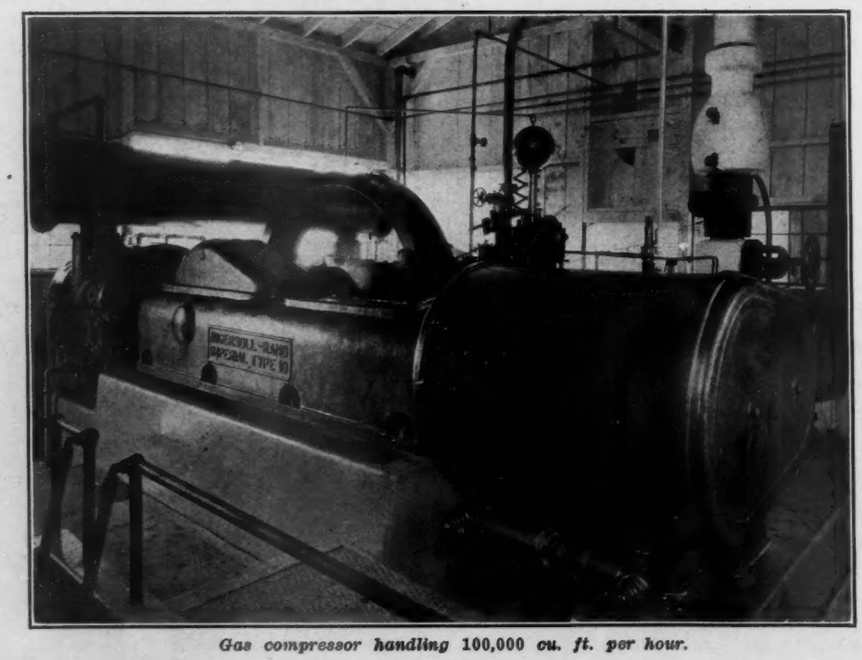
*Reprinted from "Gas Age Record."



Side view of after cooler.



Front view of after cooler.



Gas compressor handling 100,000 cu. ft. per hour.

PNEUMATIC CONVEYING AT LONDON DOCKS

AN IMPORTANT contribution to the information available with regard to pneumatic grain elevation was made by Mr. R. E. Knight, M. C., A. M. I. M. E., in his paper read before the Institution of Mechanical Engineers (London) on December 16th, 1921. There are eight different pneumatic installations in the docks of the port of London, one of which was described by the COMPRESSED AIR

MAGAZINE's Paris Correspondent in February, 1921.

Mr. Knight opened his paper with a statement of the advantages of pneumatic grain conveying, which he showed to be very great in spite of the apparently low mechanical efficiency of the system as at present evolved. He stated without reserve that "the general tendency of modern docks is to install pneumatic machines for floating discharge of ship."

The advantages of pneumatic conveying, to which he draws attention, are that there are no reasonable limitations as to the size of ship discharged; any kind of parcel and any method of stowage can be worked, with special advantage where different parcels are stowed superimposed in the same hold and separated from each other by "Matts" only. There is a great simplicity and rapidity of shipping and unshipping, and absence of "trimming" in the hold and the dust thereby entailed. There is no damage or loss of weight to the grain, but on the contrary aeration and cleaning during discharge. The use of the ship's gear is not required, and other cargoes can be removed from between decks while the grain discharge is being effected.

The work can be carried on in bad weather, owing to the minimum removal of hatches from over the hold, and while the permanent operating crew from the numerical standpoint remains about the same, the extra labor required for ploughing gangs in the hold and winch and men on the ship's deck, and the heavy charges for ropes, ploughboards, and other gear, are eliminated.

The output in tons per hour is usually higher than with other systems, but the rate of discharge with all types of machines depends more on the rate of delivery from the scales than on the intake capacity of the plant, so that the conditions of delivery largely affect the final rate of output. There is also the reliability of the pneumatic elevator and its freedom from breakdowns caused by obstructions due to foreign matter in the grain or from other cause. The costs of working and of maintenance may be shown to be made up of engineering charges and bulk grain charges, and the pnuematic elevator compares favorably with other systems in respect to engineering charges, except in the matter of capital cost.

Of the eight pneumatic grain elevating installations at work in the London Docks, six are operated by horizontal or vertical steam compound surface condensing engines, one by vertical semi-Diesel oil engines, and the eighth, which is a large four tower installation, is being converted for electric drive. This four-tower installation is known as the "Dolphins Millwall," and each tower contains a three-stage rotary exhauster with a capacity of 6,000 cu. ft. of air per minute at eleven inches of vacuum Hg. when running at a speed of 3,500 r.p.m.

Each driving motor is a direct current 220 E.H.P. motor running at a speed of 540 r.p.m. with voltage at 460 and connected to the pumps through an oil-cooled double helical speed gear having a ratio of 6½ to 1. The plant was built in 1903 and is in process of reconstruction at the time of writing in 1921.

The plant consists of a wooden staging standing at about 50 feet from the central granary quay, the staging being about 350 ft. long, 25 ft. wide and 14 ft. above Trinity high water level. The superstructure consists of the four pneumatic grain handling towers mentioned above. The improvements being carried out consist chiefly of the replacement of the steam power plant by electricity, and of the hand lever scales by automatic scales, and the inclusion of dust cyclones, wheel valves and worm conveyers for the better protection of the rotary exhausters.

These rotary exhausters consist of a rotor formed of three impellers mounted on a rigid shaft revolving in roller bearings. Air is led from the cyclone to the exhauster inlet and is discharged at atmospheric pressure or slightly above at the outlet, a butterfly valve being fitted in the inlet or suction opening. The suction side is connected to a 30-inch mercury gage and an automatic dial type vacuum recorder, and the delivery side to a 30 in. water gage. If the normal motor speed is increased to 600 r.p.m., the speed of the exhauster becomes 3,900 r.p.m., and a maximum vacuum up to fourteen inches may be obtained. The exhauster connection is through a flexible coupling to the oil cooled speed reducing gear which is in turn connected through a second flexible coupling to the electric motor, the whole being mounted with the gear and motor on a single bed-plate. The results obtained from the towers already reconstructed have been very satisfactory.

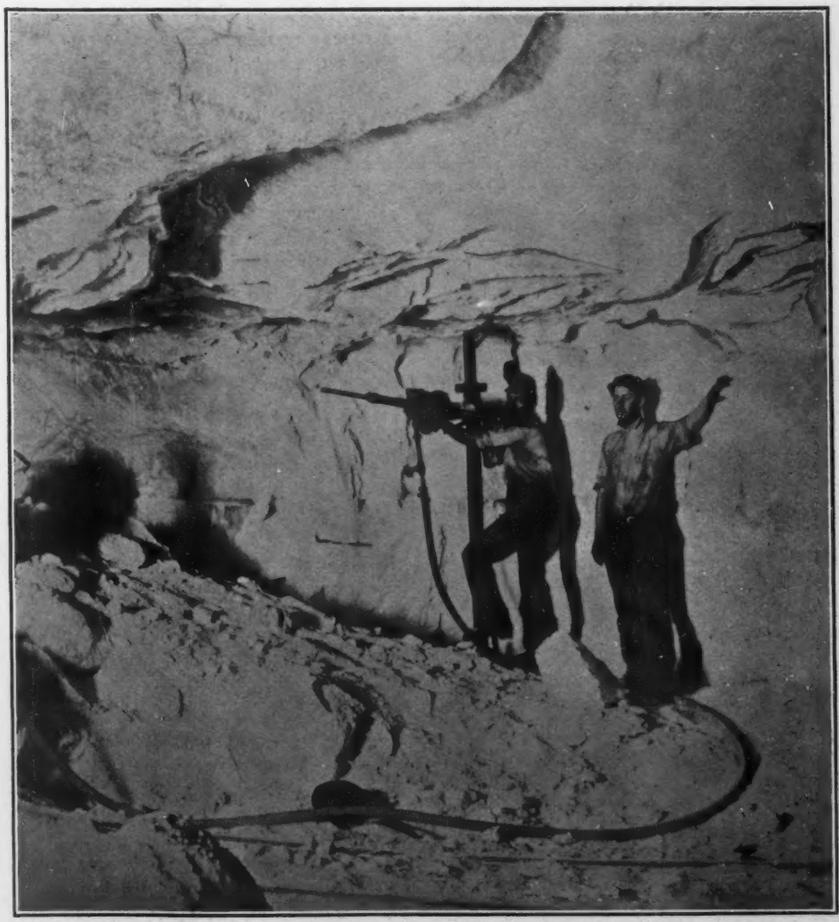
R. H. B.

MINING THE MOST COMMONLY USED MINERAL

NO USEFUL mineral except perhaps coal occurs in greater abundance or is more widely distributed in the United States than salt. It can be said that in truth salt is and has been the world's most commonly used mineral.

Commercial salt is to-day obtained from a variety of sources and by divers processes, some of which are still close to the primitive and others such as in the rock salt mine illustrated, where modern mining methods are in use. In this rock salt mine in Louisiana compressed air is operating the rock drills preparatory to blasting out this "edible ore." It is only in certain localities that conditions are favorable to employing regular mining methods, a great quantity of the salt otherwise obtained for manufacture being pumped to the surface from salt wells, natural or artificial. In artificial wells water is let down to dissolve the salt and the brine then pumped out.

However, where the ore is drilled and blasted compressed air works to advantage as it does in similar metal mining operations. Also this power medium is inherently a cleanly source of power for the drilling machines, a factor which must be observed in avoiding pollution of the salt ore. The rugged and almost wholly enclosed mechanism of the pneumatic drill avoids much of the expected tendency of the machines to become rusted when working with this salty material.



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Drilling with compressed air 700 feet below the ground preparatory to blasting salt in the mine of the Avery Rock Salt Co., Avery, La.

Compressed Air Magazine

—Founded 1896—

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EDITORIALS

THE FEDERAL RAILROAD VALUATION

WHEN CONGRESS passed the railroad valuation amendment to the Interstate Commerce Act in 1913, it was done in response to a popular demand that something definite be known of the true value of these immense properties. It was held that the Commerce Commission was constantly being called upon to fix and adjust railway rates so that, as courts had ruled, a "fair return" might be realized on a "reasonable investment." The "fair return" on public utilities properties had been pretty well established even at that time. But in the case of the railroads the amount of the "reasonable investment" upon which to compute the return was a troublesome factor.

It had long been the popular contention that the railroad properties were over-capitalized and this was one of the reasons for the valuations and another reason was that, in the event of nationalization of the railroads the figure which Uncle Sam must pay for them would be ready when wanted.

The committees of Interstate Commerce of both branches of Congress gave the valuation matter very careful consideration and hearings lasted many days and the printed record of their doings fills a good sized book.

It was upon an estimated expenditure of something like three or four million dollars and two or three years time that Congress undertook the work. The nine years that have now elapsed, however, have as yet, produced no single final valuation and have settled but few of the theoretical points involved. Up to date the work has cost approximately $60,000,000.

Railroad officials, as a rule, viewed with equinimity the prospect of an investigation of their affairs, and although entering a protest at the start, felt that good might come out of airing the account of their stewardship. However, they object to spending 60 million dollars (the railroads themselves are called upon to stand the greater portion of the expense), and nine years time on an unfinished job that should have been completed for a twentieth of that sum in two or three years time.

The Interstate Commerce Commission appointed a Bureau of Valuation to handle the matter and to work under its direction. Last year the Commerce Commission published a list of tentative valuations of some 200 railroads. Nearly all of them were comparatively small properties, none of the big trunk lines appearing. In almost every instance protest has been made and no final result can or will be arrived at till these protests have all been heard by the Commission, and till appeal has been made, if necessary, to the Supreme Court of the United States.

The valuations of the Bureau show divergent results. In the case of the Kansas City Southern Railway the tentative value reported as of 1914, amounted to $49,416,097, while the value of its 875 miles of line as carried on the company's books is more than double this sum—its funded debt alone amounting to $51,880,530, and capital stock outstanding to $52,902,700. This valuation takes no account of additions and betterments made since 1914.

Less accentuated is the case of the Norfolk and Southern Railway with its 902 miles of line. The Bureau reports a tentative value of $24,669,875, against a book account of $30,617,459. These figures, also, are as of 1914.

Later and very recently, the Bureau has reported to the Commission on the value of the Chicago Rock Island and Pacific System as of June 30th, 1915, amounting to $335,539,013, against a book value carried by the company but checked by the accountants of the Bureau of $324,098,701.

In the Spring of 1920 the Congress passed the Transportation Act which, among other provisions, required the Commerce Commission to work out a freight and passenger rate for the railroads which would produce a net operating revenue of five and one-half per cent. (six per cent. under certain conditions), on the railroad investment. It is upon the Commission's value as above that the high freight rates of 1920 were based. It is upon this valuation, for there is no other, that the reduction in rates now in progress is being based.

Although taking a keen interest in what the government is doing in valuations, most railroad men fail to see any utility in the work at all comparable with the expense involved. They feel convinced from the tentative reports now coming in, however, that the final valuations when arrived at probably through the medium of the Supreme Court, will effectually dispel the illusion of over-capitalization popularly held.

But while acquiescing in the valuation work to a certain degree—half-heartedly and none too enthusiastically—there is a school of economists to which most railroad officials belong that considers the whole theory of public utilities valuation is on trial. They reason that there is but one value of a railroad or of anything else—namely, the price it will bring in the market if offered for sale. This theory of value is as old as the hills and is just as applicable today as at any other time. They point out that a complete valuation is made of the railroads every business day in the value placed by the public on their securities in the open market. Here, they say, is to be found the only real value. It is always complete. It costs nothing. It is practical and usable.

TO ENCOURAGE THE HELICOPTER

WHATEVER MAY be our doubts and questionings as to the possible future of the helicopter it certainly promises some most desirable operative conditions if ever they can be practically realized. Both the helicopter and the airplane are absolutely dependent upon the continuous operation of the motor to raise and sustain them in the air, the one applying the power directly and the other more or less indirectly for the same purpose, so that they are more nearly akin than at first glance would appear, and the operating proposition of the helicopter is by no means so impracticable and hopeless after all. If it can ever become an established success the special advantages which it offers for general aerial operations, with its prospectively absolute control of position and speed of movement, can scarcely be overestimated.

The helicopter peculiarly invites the amateur experimenter in that the initial flights apparently do not involve the risks of immediate personal injury or even sudden death which were apparently so imminent in the first flights of the airplane. The sudden jump off into space with the sharp possibility of a drop and a smash is not primarily involved, and the first trials might be so conducted as to apparently eliminate all serious risks. This is not by any means suggesting that when fully developed and put into actual service the one type of machine will be any safer than the other.

The helicopter cannot be said as yet to have reached any permanency of type as to design or construction. Our crude understanding of it comprises a light framework carrying a high powered motor, or pair of motors, as light as it is possible to produce, these driving two normally vertical spindles rotating in opposite directions each carrying a large fan the combined lifting power of these fans being sufficient to raise the entire apparatus, with attendant and all necessary appurtenances, and to attain and maintain a sufficient height for aviation purposes. With the reliable and constant lifting ability assured all the other func-

tions of flight seem easily to follow. Simple means will give inclination sufficient to induce lateral movement, which would mean actual flying, and the steering also would be apparently easy. The resources of the inventor are all to be concentrated first of all upon the securing of sufficient and reliable power, under the necessary weight restrictions, and success here may be assumed to solve the entire problem.

Faith in the ultimate future of the helicopter seems to keep pace with, or perhaps to outstrip, the actual developments as known to the public, and substantial encouragement is not lacking. The British Air Ministry, it is reported, is seeking the sanction of the Treasury for the offering of a prize of 50,000 pounds —a quarter of a million dollars at the old par values—for a helicopter which will satisfy a series of conditions which they lay down. The competition, which will be thrown open to designers of all countries, aims to evolve a machine capable of rising by its own power to a height of 2,000 feet, carrying an airman and sufficient fuel for one hour's flight, to remain stationary for 30 minutes in a twenty mile wind, to descend in a wind of that velocity with the engine shut off without horizontal movement and to be capable of horizontal flight at a height of 2,000 feet and at a speed of 60 miles an hour.

The offering of a large reward for the production of a machine capable of doing all these things is evidence at least that there are those who do not regard it as an impossibility and their number is increasing. Great opportunities and keen inducements, it might be said, are waiting in the air for the enterprising inventor and the daring adventurer. R.

IMMENSE SUMS FROM JUNK

FINDING GOLD at the end of a rainbow is a thoroughly practical way to get wealthy, provided the rainbow happens to end in a junk-heap. Manufacturers of metal products are finding gold valued at millions of dollars in such heaps. The *Mining Congress Journal* of Washington points out that more than $200,000,000 was recovered from junk heaps and metal scraps in 1919. It quotes the U. S. Geological Survey to the effect that secondary metals were recovered from scrap, sweepings, skimmings and drosses to the value of $181,841,500. The figure for 1918 was $264,298,900. Gold, silver, platinum, iron, steel and ferroalloys are not included.

Gold and silver valued at $27,592,060 was remelted during the last year of record. Reports from mints and refineries indicated the recovery during the year of 6,463,002 fine ounces of silver and $19,354,398 in gold. Estimates of the quantity of ferrous scrap remelted during 1919 range from 7,500,000 tons to 8,500,000 tons. Platinum, iridium and palladium worth $8,053,265—or more than the value of platinum and allied metals imported for domestic consumption during the year—were also recovered.

About 287,190 short tons of secondary copper were recovered. Exports of scrap brass and copper fit only for remanufacture amounted to 661 tons of the former and 225 tons of the latter, while imports of scrap copper totaled 2,109 tons and those of scrap brass aggregated 7,933 tons.

Secondary lead recovered aggregated 122,100 short tons. Secondary zinc recoveries aggregated 108,404 tons, or 23.3 per cent of the year's output of primary zinc; antimony, all of which except forty-eight tons was recovered from alloys, 4,399 tons tin, 24,033 tons valued at $29,868,200, aluminum, 18,691 short tons valued at $12,014,600, nickel, 2,447 tons. It is well known that the recovery of secondary metals has been an important industry for many years, but the figures here quoted show to what extent this market competes with production from our mines. It would seem that along these lines the metallurgist's art has reached perfection.

ATOMS ENSLAVED

(Reprinted from New York Herald).

Out in Chicago, which is now the centre of most scientific culture, a model of a molecule is on exhibition. It is 250,000,000 times the size of the subject, according to the sculptor, Professor JARED K. MORSE. Inside the molecule, of course, are atoms.

Professor MORSE says there is no doubt now that molecules and their atoms are busy little things, on the move all the time. And they proceed just like the solar system, one set revolving around some boss atom just as the earth and other planets revolve around the sun.

This sort of thing is all wrong, as H. G. WELLS knows. Why should one atom be honored above his fellows by having them as satellites? Don't molecules and atoms know that in the ideal state nothing revolves about anything except itself? So long as any atom pretends to be the centre of anything Civilization will keep on tottering to its fall, just as it has tottered since ADAM'S day.

It is an outrage that there should be system among atoms when the Third Internationale has pointed the way to perfection through confusion. Let molecules and atoms rise and strike down their oppressors. Why should they spin on and on?

THE ECONOMICS OF GOLD MOVEMENTS

SETTLEMENT of international trade balances by the physical transfer of gold is a practice which is as old as the hills. The records of the United States Department of Commerce show that, during the past 37 years, fully seven billion dollars worth of gold coin and bullion have entered and left this country as imports or exports as the exigencies of foreign trade balances have demanded. If one were to examine the gold movements of the entire world during this period it is safe to say that an amount of gold far in excess of the entire world's stock had been moved about, back and forth, between the nations.

The causes behind the enormous influx of gold to this country in recent months and years are too well known to be enlarged upon. Being unable to settle balances by the return of goods and in order to keep their credit half-way good, merchants and bankers of foreign countries as well as the governments themselves, have simply *had* to send over gold instead. This is a wholly abnormal condition and will right itself in time. Some day the trade balance between this and some foreign country will demand that we ship some of our gold—indeed, such a condition is now developing in the case of Switzerland whose money has recently become at a premium in the United States—the only country in the world where the dollar is at a discount. This circumstance may call for the shipment of gold Swissward at almost any time.

The cost of shipping gold is a factor to be reckoned with. Prior to the war it may be stated at about one-half of one per cent. of the value of the shipment, or $0.005 per dollar of value—$0.0243 per pound sterling. During the war and the year or two which followed, the cost increased considerably. At the present time it amounts to approximately one per cent. of the shipment value. This cost includes freight, insurance, loss of interest while in transit, brokerage, packing, teaming, guarding the shipments, clerical work of counting at each end, and a variety of petty expenses.

The export and import of gold in this country is entirely in the hands of private individuals —financiers, banks and bankers. Except for such regulation as was necessary during the war—regulation which was abandoned very shortly afterwards—this government exercises no direct control over gold movements. At present rates of exchange between this and all other countries it is cheaper for United States bankers with international balances to settle, to buy bills of exchange rather than to ship gold. It is this fact that is keeping our immense stock of gold here. In ordinary times bankers weigh the cost of purchasing bills of exchange on their creditor country, against the cost of shipping the gold and this is the determining factor. If it is cheaper to ship gold, over it goes.

Economists have long recognized the loss which occurs every year by the constant movement of gold—the same coins and bars—backward and forward, over and over again—to Tokio; to Rio Janeiro; to London; to Rome; Calcutta and back to New York. Always on the move—eating itself up—an uneconomic, useless drain upon resources because of the fact that gold, being the only form of universally accepted international currency, is considered by its owner, unsafe in the hands of anyone but himself.

The seven billion dollars of gold coin and bullion which have sailed the seas, back and forth to and from this country for the past 27 years have cost "somebody" an enormous sum of money. At an average cost of, say, one per cent, the bill has amounted to $70,000,000, which has been set down as a purely economic waste, and you and I (the public) have paid the bill.

Why? Not because the bankers and merchants of this country do not trust the bankers and merchants of other lands, nor because they do not trust us. It is because the world has never been entirely free from the menace of war, and in case of war large balances of gold in the hands of an enemy nation would spell disaster to the actual owner, and would bring comfort to the enemy.

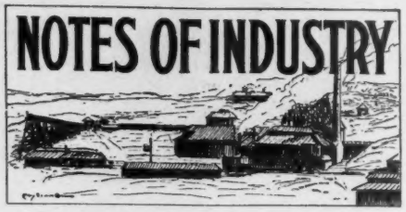
It has been suggested that the naval holiday

which may be the outcome of the limitation of arms conference may change all this—that, for a period of ten years, a confidence among nations may be created so that it will no longer be necessary for the owners of gold to have the actual metal in their own physical possession.

It is by no means unreasonable to expect that with the absence of war menace during that period—and perhaps longer—it will be possible for the world's gold to be held much as the gold settlement fund of the Federal Reserve banks is now held. Under this arrangement all of the gold belonging to the different reserve banks is lodged in one place. Its actual distribution of ownership is accomplished by a mere matter of bookkeeping—the changing ownership from day to day being recorded by a simple ledger entry—the gold never moving. With reasonable assurances of peaceful conditions, a banker in London would feel perfectly safe if the gold due him under a certain transaction were held to his account in the vaults of his correspondent bank in Valparaiso or San Francisco as if it were in his own physical possession. A New York banker need not, then, send gold to his creditor in Antwerp because the Belgian would be just as well satisfied and would be just as safely protected if the amount were held to his credit in this country.

Gold movements may be compared with the daily transactions one has with his bank in ordinary domestic commercial affairs. One does not insist on actually seeing, holding and handling his money, his gold, represented by his bank balance, although the bank is under obligation to let him do so if he chooses. But he does not choose. He is content to take the bank's word for it that his money is there. When he has payments to meet, he does not convey the gold to his creditor, nor does the creditor expect it. Both are content to take the word of the bank and one to give and the other to receive a simple draft, or obligation or check which performs the journey from the debtor to the creditor expeditiously and cheaply. Nor does the bank receiving the draft of check and placing it on deposit to the account of the creditor, insist that the bank upon which it is drawn shall forward the gold to make it good. It is done in a much simpler way. A book entry does the work and the Clearing House attends to the rest.

Signs are not lacking that the financial world is coming to the conclusion that the economic waste of gold movements can be avoided—at least, in a measure. A very considerable amount of the gold reserve of France is held outside that country. As a result of a favorable trade balance preceding 1917, Japan found herself with $400,000,000 in gold due her from this country and Great Britain. Being an ally of both of these nations in the war and without the slightest anticipation of trouble on the Pacific from the Germans, she elected that this gold remain to her credit where it was, thus saving the transportation expense. It is thus that, for several years, the United States retained physical possession of something like $290,000,000 belonging to Japan and England held the remainder amounting to approximately $110,000,000.



It seems that as yet we know very little of the available supply of oil in the world, and we might as well stop worrying about it. Extensive oil fields as well as coal and shale deposits have recently been discovered on the Mackenzie River in the Canadian Northwest. According to the reports these oil fields are the richest so far discovered on the American continent. There are vast areas of the earth of which little is known or which have little on the surface to invite men's occupancy but which may be presumed to be as rich in oil and minerals as other portions of the earth and they will be explored and developed as the necessities or incentives increase.

A NON-STOP run of 6,527 miles, which is said to be the longest on record, has just been accomplished by the new Pacific Steam Navigation Company motor boat *Lobos,* of 9,000 tons. Having left Liverpool on October 26th, the *Lobos* arrived at Bahia Blanca, Argentina, on November 20th, without once having stopped her engines.

The Paris Prefect of Police is providing his force with a number of motor cars equipped with wireless telephone apparatus, from which it will be possible at any moment to telephone to headquarters or to one another. In the pursuit of criminals and in other police operations requiring great rapidity, much time otherwise lost in using the ordinary public telephone offices, often some distance from the scene of the proceedings, will thus be saved, and the chances of success correspondingly increased. The only point remaining to be settled is the wave length to be used.

According to the United States Bureau of Standards, as many people in New York take trips on elevators as on all the city traction lines. An elevator in the Woolworth building travels forty miles in a day, making 4,000 stops. Unfortunately, the safety record for the elevators is largely flavored with unsafety, and still calls for absolute interlocking devices and other precautions.

Advices from Consul A. E. Southard, at Jerusalem, to the Department of Commerce indicate that the Russian engineer who plans to use the waters of the Jordan and other rivers in Palestine for hydroelectric power has left Jerusalem for Germany, and that he expects to be in London in January and leave for the United States about February 1.

The Ninth National Foreign Trade Convention of the National Foreign Trade Council will be held in Philadelphia on May 10, 11, 12, 1922, according to the announcement of O. K. Davis, Secretary of the Council.

Scientific Paper No. 419 has just been issued by the Bureau of Standards. It deals with the production of liquid air, bringing together valuable information on the subject. It may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 5 cents a copy.

American interests are progressing satisfactorily in the development of foreign oil fields, according to Mr. Hoover, Secretary of Commerce. Exploration and development operations have been begun in South American and other fields as a result of the government's appeal for cooperation by American oil companies to provide future oil supplies for the United States, it was said. American companies are also reported to be active in northern Canada, while operations in European and Asiatic fields are understood to be limited because of the strong position of British interests.

The Philadelphia office of the Hauck Manufacturing Company, manufacturers of portable oil burners, torches, furnaces, etc., has been moved to 1726 Sansom Street. Mr. Herbert Vogelsang, who has been connected with the Hauck Manufacturing Company for six years, will be in charge.

"The Rathbun Jones Engineering Company, Toledo, Ohio, has appointed the Ingersoll-Rand Company, New York, General Sales Agent for Rathbun Gas Engines. The large sales organization and service department of the Ingersoll Rand Company, combined with the fact that gas engines are used to drive compressors, pumps and other machinery which it manufactures, places it in a position to serve better the users of gas engines and other machinery.

"Rathbun Gas Engines are well-known to the trade as they have been in successful operation for over twenty years. They are of the vertical, multi-cylinder type and are built to operate on natural, illuminating, producer, coke oven, oil still and other forms of gases which can be successfully handled in an internal combustion engine. Sizes range from 100 brake horse power to 1450 brake horse power."

"Clean, Dry Air and Increased Machine Efficiency" is the slogan of a bulletin received from the Midwest Steel & Supply Co., Inc., manufacturers of the Midwest Unit Air Filter. The removal of impurities from ordinary atmospheric air for use in compressors, gas engines and similar machinery is shown as important to the life of the machines. The construction and functions of the Midwest Air Filter are then discussed in detail. This filter it is claimed depends upon entirely new principles of air or gas filtration; the air or gas being drawn or forced in ever changing directions through filter "units" containing numerous small metal cylinders with very large aggregate surface. The small metal cylinders are moistened with a liquid called "Viscosine" by which the air is cleaned through precipitation and adhesion of the dust. Over 1500 installations, it is said, have been made of these filters.

ELEMENTS OF MECHANISM, by Schwamb-Merrill-James. Peter Schwamb, S. B., Professor of Machine Design, Allyne, L. Merrill, S. B., Professor of Mechanism, and Walter H. James, Assistant Professor of Mech. Eng. Drawing, all of Mass. Inst. of Tech. Third Edition, Rewritten, Reset and Enlarged. 372 pp. 6x9, 426 figures. Cloth, $3.50 net. New York: John Wiley & Sons, Inc.

THIS BOOK is now thoroughly revised, and includes many changes suggested by instructors who have used the previous edition. The entire book has been reset in more attractive type and new illustrations have been added. In its present form it is representative of the latest practice.

The "Elements of Mechanism" is intended as a basis for instruction in mechanism followed by a study of the mechanism of machine tools and of cotton machinery. Having been carefully revised it is now a superior text, and worthy of attention by all concerned with the study of mechanism.

It was first written in the form of notes in 1885, and was published in book form in 1904.

The present issue is the 30th thousand.

WORDS WE MISSPELL IN BUSINESS, by Frank H. Virgetelly, Litt. D., LL.D., author of "Essentials of English Speech and Literature," "A Deskbook of Errors in English," and managing editor of Funk & Wagnalls New Standard Dictionary. 250 pp. New York: Funk & Wagnalls Company.

IN THE compiling of this book the purpose kept in mind was to supply a guide to correct spelling that would serve persons engaged in commercial pursuits. To that end the author has gathered together some ten thousand terms and shown their correct forms and divisions as used in printing and writing.

The book is not intended as a primer of spelling but rather as a guide to the words too frequently misspelled in business communications. The vocabulary embraces terms that have been collected by the writer during thirty years of active business life devoted to the production of books. Each word has been syllabicated in such a way that the proper division may be seen at a glance.

CONQUESTS OF INVENTION, by Mary R. Parkman, author of "Fighters for Peace," "Heroes of Today," etc. Illustrated, 400 pp. Cloth, $2.00. New York: The Century Co.

HOW MAN has solved the practical problems of food, clothing, shelter, lighting, transportation and communication is given through the dramatic stories of great inventors and their work. This book presents epoch-making chapters in the development of civilization, in a manner which is interesting and easily readable.

The story of Cyrus McCormick and his reaper tells of the feeding of millions; Hargreaves, Arkwright, Cartwright, in England, tell of the passing of the spinning-wheel and the hand loom. Eli Whitney gives American cotton its place in the markets of the world and Elias Howe's sewing machine brings freedom from household drudgery. The stories of Charles Goodyear, who made the wheels of progress rubber-tired, and of Murdock and Edison, who proved what artificial light could do for civilization, are followed by the epic of transportation, including sketches of James Watt, Stephenson, Fulton, Westinghouse, Ford and the leaders in the conquest of the air—Langley and the Wrights. Another section deals with communication and the triumphs of Morse, Thompson, Bell, Marconi and Carty.

Brief synoptic chapters giving a bird's-eye view of each epoch serve as a general introduction to the group of biographical narratives.

The Direct Separator Co., Inc., has issued an illustrated pamphlet with tables and diagrams describing the Sweet Separator including a paragraph on their use in compressed air lines for the removal of water particularly in sand blasting outfits, vibrators, jolt rammers and in a number of other places where they reduce expense and trouble. The use of oil separators and steam separators is also discussed. These separators are made in a great many special forms, from the smallest weighing 50 lbs. to the largest weighing 32,000 lbs.

A folder also supplied by the same company gives the result of a test on the performance of a sweet steam separator at the Eliza Furnace, Pittsburgh, Pa., showing the advantage of its use.

The Sprague Electric Works have issued an attractive bulletin featuring the Sprague Electric Dynamometer (Research Type). It describes numerous applications of this apparatus for the measurement of torque or power. This dynamometer is today an essential instrument in reliable research throughout the automotive industries, in government laboratories, and in scientific and technical schools.

A review of the engineering accomplishments of the Westinghouse Electric & Manufacturing Company for the year 1921 has been received. While only a condensed account of the various engineering achievements is given, the review fully demonstrates that this company has maintained during 1921 its past record for notable electrical engineering developments. That rapid strides are being made in the development and application of electrical equipment which are making possible the more economical generation and use of electrical power, with material saving in our natural resources, is shown in a very convincing manner by this record of progress.

The Uehling Instrument Company has prepared two very instructive bulletins dealing with the Magnitude of the Power Plant's Chimney Loss (No. 220) and the Relation Between CO_2 and Money Wasted Up the Chimney (No. 221). Each contains valuable tables and charts concerning losses involved in the combustion of fuel for industrial purposes.

The General Offices of the Pneumercator Company, Inc., have been removed from 15 Park Row, New York City, to Sperry Building, 40 Flatbush Avenue Extension, Brooklyn, N. Y.

Dr. Charles Baskerville, Director of the chemical laboratories of the College of the City of New York, died recently at his home in New York in his 55nd year. Dr. Baskerville was the author of a number of text books on chemistry and contributed many scientific articles. His researches embraced work on rare elements, on anesthetics and on many phases of industrial chemistry.

* * *

William H. Bradley, of 23 East Sixty-eighth Street, since 1886 chief engineer of the Consolidated Gas Company, died suddenly of heart disease in his office in the company's building at 130 East Fifteenth Street a few days after expressing a wish to "die in harness." He was born in New Haven, Conn., in 1838, and in his early twenties became a construction engineer with the Continental Iron Works of Brooklyn. This firm built Ericsson's Monitor, young Bradley helping in the work.

* * *

The Hon. William C. Redfield, former president of the A. M. E. A., has been elected president of the Netherlands Chamber of Commerce in New York, Inc. Mr. Redfield fills the vacancy caused by the resignation last summer of N. G. M. Luykx, vice-president of the Sinclair Consolidated Oil Corporation, who, because of stress of business, deemed it advisable to surrender the office.

* * *

F. M. Feiker, vice-president of the McGraw-Hill Publishing Company, who for the past eight months has been assisting Secretary of Commerce Herbert Hoover in the reorganization of the department has resigned. Mr. Feiker has not, however, completely severed his relations with the Secretary or the department. He has been appointed a special agent of the Bureau of Foreign and Domestic Commerce, to continue in a consulting capacity the work he has been rendering.

* * *

Mr. O. M. Rau, formerly consulting engineer to the Philadelphia Rapid Transit Co., has now become associated with the Hardinge Company, Incorporated, 120 Broadway, New York, and will specialize in the handling of Quigley pulverized fuel systems as applied to boilers. Mr. W. O. Renkin has also become associated with the Hardinge Company. These changes took place with the acquirement by the Hardinge Company, Incorporated, of the Quigley Pulverized Fuel Department of the Quigley Furnace Specialties Co.

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Mr. R. C. Wells, chemist on the staff of the U. S. Geological Survey, was elected president of the Chemical Society of Washington at the January meeting.

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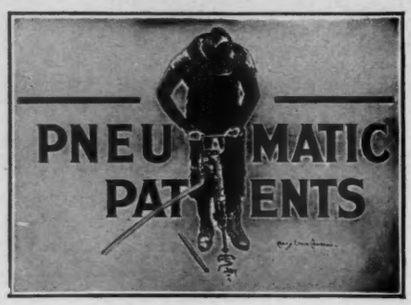
The next Universal Postal Union Congress will be held at Stockholm in 1924.



NOVEMBER 8

1,396,079. AIR-PUMP. Robert Warnock, Bloomfield, N. J.
1,396,237. FLUID-PRESSURE SYSTEM. Vincent V. Veenschoten, Erie, Pa.
1,396,263. VACUUM-CLEANER. Jacob W. Diephouse, Chicago, Ill.
1,396,319. AIR-BLAST SPRAYER. Alvin B. Chaplin, Tuckahoe, N. Y.
1,396,391. POWER-OPERATED COMPRESSOR. Frank Ackerman and Charles W. Frees, St. Louis, Mo.
1,396,449. PNEUMATIC-DESPATCH APPARATUS. James G. Maclaren, Mamaroneck, N. Y.
1,396,494. AIR-PUMP. Richard Wright, Philadelphia, Pa.
1,396,632. METHOD AND APPARATUS FOR TREATING LIQUIDS. Aage Jensen, Portland, Oreg.
4. An apparatus for treating milk, cream and the like, comprising a plurality of containers, means for applying a vacuum thereto, a pasteurizing apparatus, and connections between each of said containers and said pasteurizing apparatus for permitting a continuous circulatory movement of the material being treated through any one of said containers and said pasteurizing apparatus.

NOVEMBER 15

1,396,785. COOLING MEANS FOR MOTOR-VEHICLE ENGINES. George L. Schofield, Kansas City, Mo.
1,396,823. OIL-BURNER SYSTEM. Milton A. Fesler, Oakland, Calif.
1,397,045. APPARATUS FOR SPRAYING BINDING MEDIA ON ROADS. Sam Everett Finley, Atlanta, Ga.
1,397,416. FOOT-OPERATED PUMP FOR PNEUMATIC TIRES. George J. Fleure, Brooklyn, N. Y.
1,397,473. GAS AND AIR MIXING DEVICE. Charles H. Werlin, Columbus, Ohio.

NOVEMBER 22

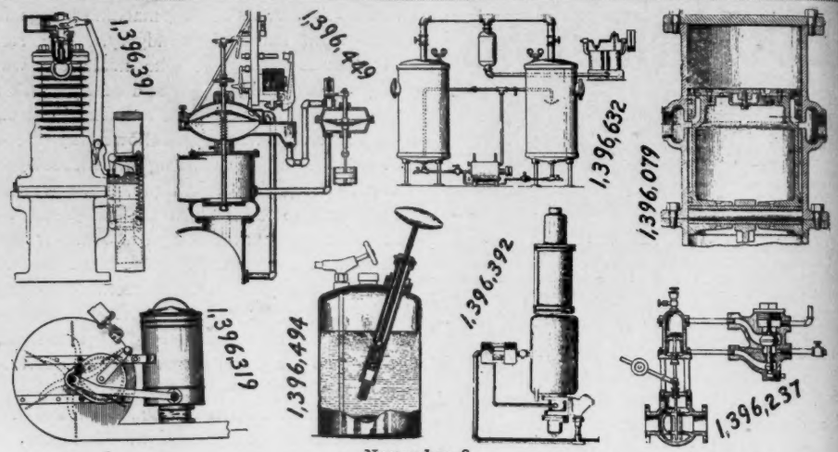
1,397,704. DRY-PIPE VALVE. George I. Rockwood, Worcester, Mass.
1,397,829. AIR-PUMP FOR AUTOMOBILES. William A. Wilson, Minneapolis, Minn.
1,397,877. COMPRESSED-AIR PUMP. Willie Milam, Winston, Ga.
1,397,914. AMMONIA-COMPRESSOR. Edwin J. Augustin, Wauwatosa, and George Bauer, Milwaukee, Wis.
1,397,988. ORGAN-BLOWER. Rowland Henry Smith, Brantford, Ontario, Canada.

NOVEMBER 29

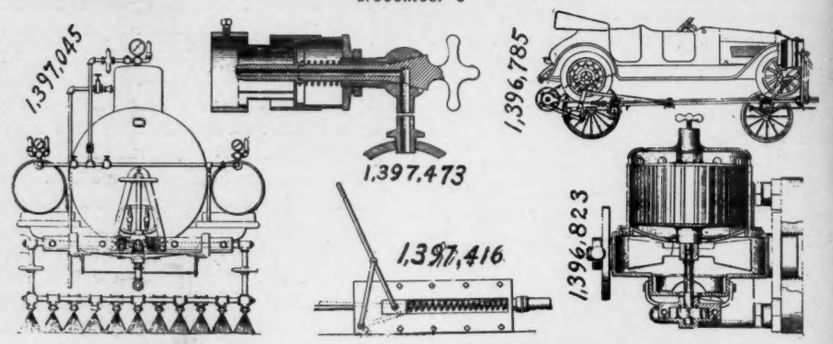
1,398,246. APPARATUS FOR SUPPLYING AIR TO THE EXTERIOR OF HULLS OF SHIPS. F. G. Trask, Ross, N. D.
1,398,309. COMPRESSOR VALVE MECHANISM. William Wishart and Albert H. Morrell, Clinton, Iowa.
1,398,527. INSTRUMENT FOR SUPPLYING COMMINUTED GOLD BY AIR-PRESSURE. Frederic James Muspratt, township of Woombye, Queensland, Australia.
1,398,550. AIR-LIFT BOOSTER. Halbert B. Halvorsen, Chicago, Ill.
1,398,912-3. COMPRESSOR - CONTROLLING MECHANISM. Wade H. Wineman, Chicago, Ill.
1,398,920. AIR-BRUSH. Augustine Shelburne, South Pasadena, Calif.

DECEMBER 6

1,399,010. MEANS FOR ATOMIZING AND IGNITING LIQUID FUEL. Abner Doble, Detroit, Mich.
1,399,095. VACUO-THERMIC-BODY-TREATMENT APPLIANCE. Jean F. Webb, Sr., New York, N. Y.
1,399,099. VACUUM-BRAKE. Harry W. Barrows, Omaha, Nebr.
1,399,151. AIR-COMPRESSOR. Delmer M. Putnam and Harley M. Dunlap, Battle Creek, Mich.
1,399,223. FLUID-OPERATED MOTOR. Gustave M. Nell, Denver, Colo.



November 8



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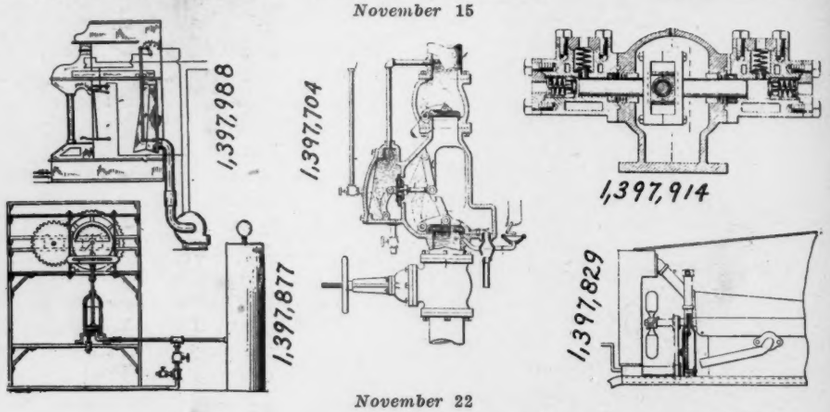

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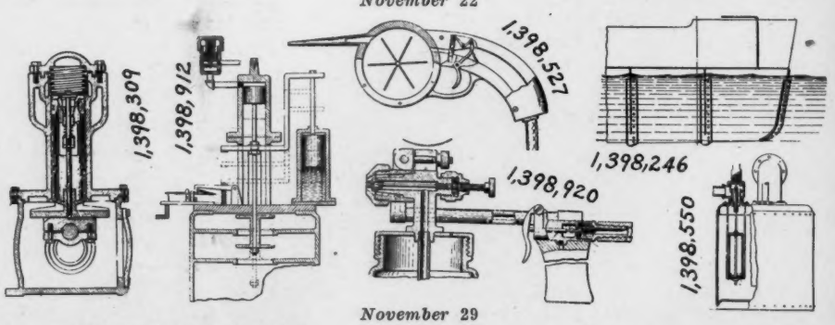

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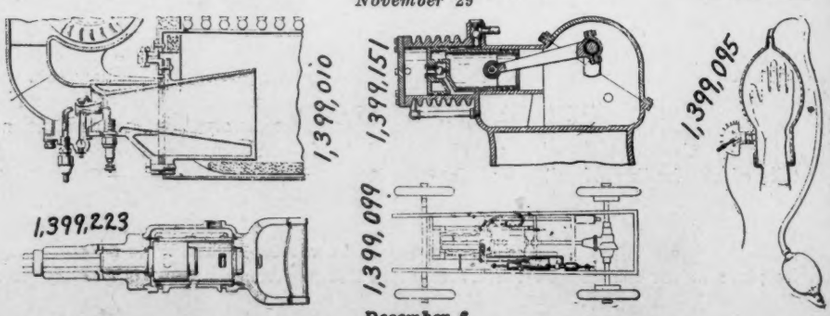

December 6